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# *Opuscula Philolichenum*

*small works in the field of lichenology*

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## MISSION

*Opuscula Philolichenum* is intended to serve as a venue for the publication of small works in the field of lichenology (including lichenicolous fungi and non-lichenized fungi traditionally treated with lichens). The central goal of the journal is to provide timely publication, in a professional format, free of charge to authors and readers. While the journal focuses on topics relating to the lichen biota of North America this is by no means exclusive and manuscripts on other topics will be considered as the table of contents of the present issue clearly illustrates.

Authors wishing to submit a manuscript for publication in *Opuscula Philolichenum* should contact the editor prior to submission to confirm that the paper conforms to the mission of the journal (outlined above). Manuscript submissions should be left unformatted and authors should consult a recent issue of *Opuscula Philolichenum* for style. All submissions are subjected to review by at least two peer reviewers and, following acceptance are formatted by the editor.

## NOTICE FROM THE EDITOR

When this journal began publication ten years ago it was among the first serials to take advantage of the internet when publishing new botanical nomenclatural acts. The journal was conceived as a primarily electronic one, available on-line free of charge (at <http://sweetgum.nybg.org/philolichenum/>), with a limited print run to satisfy the requirements for effective publication established under the *International Code for Botanical Nomenclature*. Since that time we have continued to publish the journal in this manner, printing one or two issues a year, with each issue consisting of between one and two hundred pages.

In 2004 we could not have foreseen the revolutionary changes that took place at the 18<sup>th</sup> International Botanical Congress in Melbourne. There the Nomenclature Section voted to allow electronic only publication of new nomenclatural acts beginning 1 January 2012. In response to this change *Opuscula Philolichenum* no longer produces hardcopy. Although a single printed copy will continue to be deposited in the library of The New York Botanical Garden.

Beginning with volume number 12 of *Opuscula Philolichenum*, manuscripts are published electronically on-line in PDF/A format immediately following the approval of the authors in the post-review proof stage. The PDF issued online is considered to be the final version (= version of record) and the date on which the PDF is posted is considered to be the date of effective publication. In order to aid future workers the date of effective publication for each manuscript is provided in the table of contents. When a new manuscript is published online a record is also simultaneously transmitted to the organizers of *Recent Literature on Lichens* for inclusion in that database.

# Table of Contents

Front Matter	i-iv.
<b>effectively published online 28 February 2023:</b>	
Diaz, V. and E.A. Manzitto-Tripp. A synopsis of the yellow-green, usnic acid-producing, species of <i>Xanthoparmelia</i> in Colorado.	1-40.
<b>effectively published online 17 July 2023:</b>	
Brinker, S.R. Further contributions to the Ontario flora of lichens and allied fungi, with emphasis on the Great Lakes Basin.	41-80.
<b>effectively published online 1 November 2023:</b>	
Lendemer, J.C. Studies in Lichens and Lichenicolous Fungi – No. 23: Notes on Appalachian taxa including newly reported disjunctions and multiple species new to North America.	81-97.



## A synopsis of the yellow-green, usnic acid-producing, species of *Xanthoparmelia* in Colorado

VANESSA DIAZ<sup>1\*</sup> AND ERIN MANZITTO-TRIPP<sup>2,3</sup>

**ABSTRACT.** – The genus *Xanthoparmelia* belongs to one of the largest and most species-rich foliose lichen families - Parmeliaceae. It occurs primarily in arid regions around the world. In the United States, *Xanthoparmelia* is extremely abundant in the southern Rocky Mountains and adjacent high plains of Colorado, where species play significant ecological roles. The present study emphasizes the examination of type material, protologues, study of new field collections as well as existing herbarium material, data from thin layer chromatography, and information on species distributions to delimit species of non-melanin-containing (i.e., yellow-green) members of *Xanthoparmelia* in Colorado, U.S.A. Using the University of Colorado Herbarium (COLO) collection in addition to collections made by the authors, a total of 18 species belonging to five different chemical groups are recognized as occurring in Colorado. *Xanthoparmelia arseneana* is placed in synonymy with *X. novomexicana*. In addition, two species are excluded from Colorado: *X. taractica* and *X. hypopsila*. A dichotomous key and a species treatment that includes type citations, morphological descriptions, chemical information, and geographical distributions is included. This treatment is the first to focus on this abundant yet taxonomically challenging lineage solely in Colorado.

**KEYWORDS.** – Biodiversity, Boulder County, chemistry, foliose lichens, Parmeliaceae, Thin Layer Chromatography, TLC.

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### INTRODUCTION

The family Parmeliaceae is one of the most species-rich lineages of lichens, consisting of over 2,000 recognized, primarily foliose species (Del Prado et al. 2007; Lücking et al. 2017; Thell et al. 2012). With over 800 species, the most species-rich genus within the family is *Xanthoparmelia* (Vain.) Hale (Amo de Paz et al. 2010b; Hale 1990; Leavitt et al. 2012), which is globally distributed but especially diverse in several areas including Australia (McCarthy 2003) and North America (Esslinger 2021). Species of *Xanthoparmelia* encompass a broad range of ecologies, but most preferentially inhabit arid regions such as low- to mid-elevation deserts, grasslands and shrublands (Barcenas-Peña et al. 2018). However, numerous species occupy wetter environments ranging from high alpine ecosystems to temperate forests (Debuque et al. 2015; Hale 1990; Leavitt et al. 2011a; Knudsen et al. 2017; Tsurykau et al. 2018). In North America, western mountainous portions of the United States are particularly species-rich (Nash and Elix 2004). In areas such as the southern Rocky Mountains and Sierra Nevada Mountains, species of *Xanthoparmelia* are among the most abundant and ecologically important lichens, where they contribute conspicuously to saxicolous communities in the plains to the foothills to the high peaks of the alpine ecozone (Hale 1990; Leavitt et al. 2011b; Leavitt et al. 2013).

*Xanthoparmelia* was first introduced as a section of *Parmelia* Ach. by the Finnish lichenologist Vainio (1890) to delimit the foliose yellow-green group of parmelioid lichens, which derive their

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characteristic color from the presence of usnic acid in the upper cortex (Hale 1973). Historically, morphological and chemical features in addition to reproductive modes were heavily relied upon to help characterize taxa in this species-rich genus (Blanco et al. 2004). However, as molecular data have continued to accumulate, it has become apparent that earlier methods are both insufficient and at times misleading when estimating species numbers and limits in the group (Amo de Paz et al. 2010a; Blanco et al. 2004; Leavitt et al. 2016). Molecular analyses have further demonstrated a number of previously segregated genera (e.g., *Neofuscelia* Essl., *Almbornia* Essl., *Xanthomaculina* Hale, *Paraparmelia* Elix and J.Johnst., and *Namakwa* Hale) are phylogenetically embedded within *Xanthoparmelia* (Amo de Paz et al. 2010a; Blanco et al. 2004; Elix 2003; Thell et al. 2004, 2006).

Thus, *Xanthoparmelia* as now delimited is markedly different than as originally circumscribed by Vainio (1890), including not only the iconic yellow-green foliose species but additionally others with gray or brown thalli, as well as subcrustose species. These taxa nonetheless share *Xanthoparmelia*-type lichenan in the cell walls, diverse medullary chemistries, and most commonly occur in arid to semi-arid environments (Blanco et al. 2004, 2006; Thell et al. 2006).

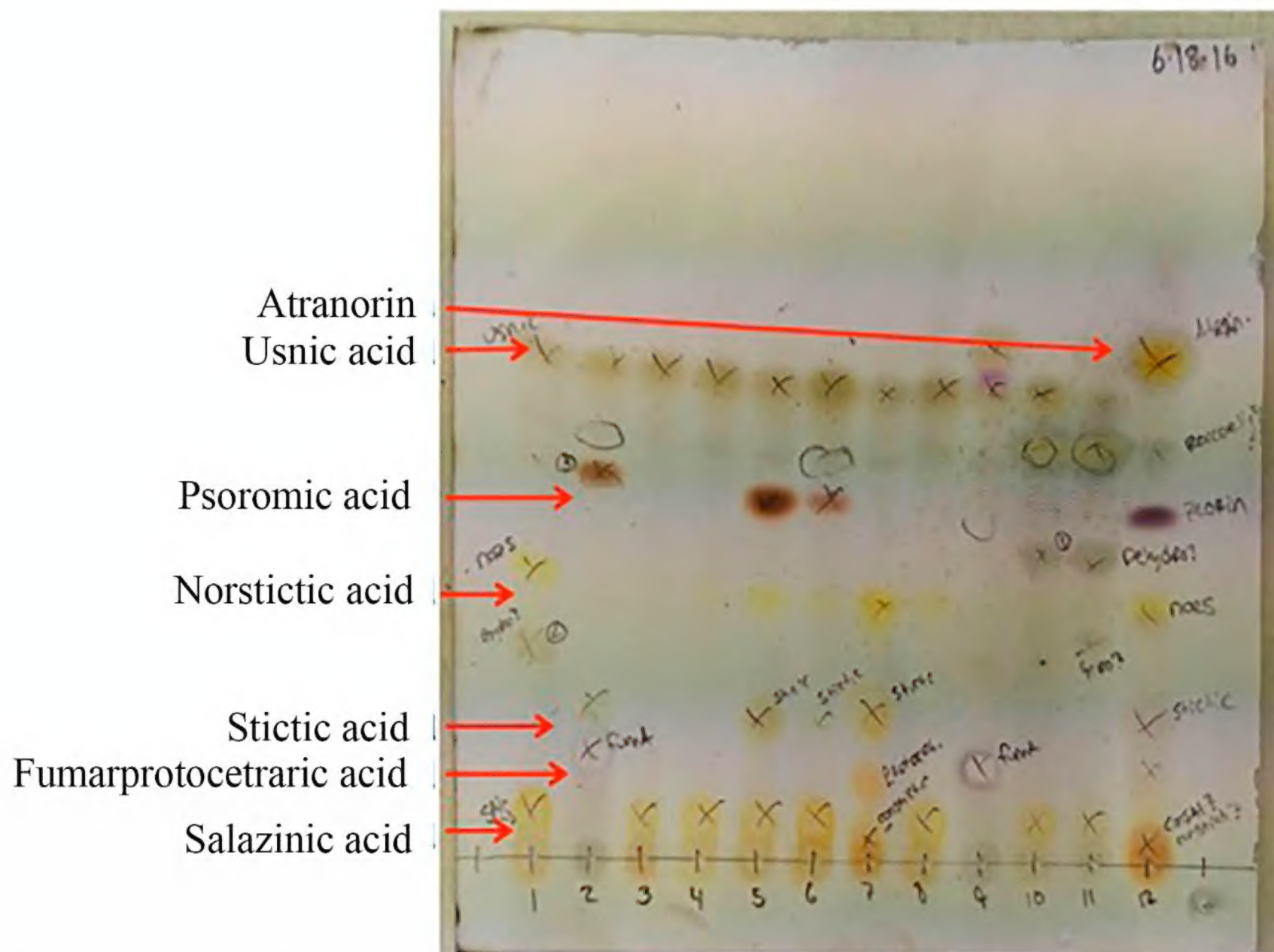
In the field, the yellow-green species *Xanthoparmelia* can be particularly difficult to distinguish from one another. As numerous prior authors have discovered, closely related species can be nearly indistinct morphologically (i.e., they share the same lower cortex color, spore morphology, medulla and algal structure, and lobe morphology; Benedict et al. 1990; Hale 1990). Lichenologists have in turn capitalized on metabolic differences to aid in identification (Giordani et al. 2002; Hale 1990; Sanders 2011). However, molecular data have called into question the utility of only chemotaxonomy and/or morphological features to delimit species of *Xanthoparmelia* (Leavitt 2011a, 2012, 2016). This sentiment applies particularly well to *Xanthoparmelia*, where chemistry has been heavily relied upon for species circumscriptions. Recent progress in molecular phylogenetics has fostered a new understanding of the problem of “chemovariants” in *Xanthoparmelia* and is challenging current species delimitations (Blanco et al. 2006; Leavitt et al. 2011a, 2012, 2018; Grewe et al. 2017; Meiser et al. 2017). Although it is clear that more molecular, morphological, and chemical analyses are needed to best determine how to delimit species in this group, it is nonetheless important to continue to build the foundation of field-based approaches that will in turn enlighten comparative molecular, morphological, and chemotaxonomic studies.

The goal of the present study was to re-assess nomenclature and taxonomy of usnic acid-producing species of *Xanthoparmelia* that occur in the southern Rocky Mountains and adjacent high plains and basins of Colorado. Prior studies have demonstrated that species of *Xanthoparmelia* are both exceptionally diverse in Colorado as well as difficult to identify owing to the presence of chemovariants, non-monophyly of previously recognized species, ecological abundance, niche overlap, and poorly defined geographical ranges of taxa (Brodo et al. 2001; Leavitt et al. 2012; Nash and Elix 2004; St. Clair 1999; Thell et al. 2012). The present contribution represents a first attempt to delimit the diversity of this subset of *Xanthoparmelia* within Colorado specifically. Our objectives were to: (1) contribute an account of total diversity of *Xanthoparmelia* in Colorado; (2) ground this study in an extensive review of type material and protologues of all names; and (3) present a first dichotomous key to the species of usnic acid-producing *Xanthoparmelia* in Colorado. This synopsis was based primarily on a review of the 277 existing specimens housed at the University of Colorado (COLO) Herbarium supplemented by ~100 new voucher specimens collected for this study. The resulting species accounts include morphological descriptions as well as chemical circumscriptions as determined through Thin Layer Chromatography

## MATERIALS AND METHODS

*Field, Herbarium, and Curatorial Work.* – To help understand diversity of *Xanthoparmelia* in Colorado, we collected new voucher specimens throughout Boulder County between June-October 2015; we additionally incorporated field collections (made by us) from other localities throughout the state. Field sites ranged from highly disturbed cattle pastures to little manipulated montane areas. Elevations at new collection sites ranged from 1615-1920 m (5300-6300 ft) in Boulder County, and at elevations below 1524 m (5,000 ft) and above 3962 m (13,000 ft) elsewhere in Colorado. New field collections were made both on and off trail, with permits provided by the City of Boulder’s Open Space and Mountain Parks Program and by the US Forest Service. In total, 80 new field collections were made as part of this study by the first author, and these collections were supplemented by 10 others made by the second author. All specimens were deposited into the COLO Herbarium and data are available via COLO’s database (<https://botanydb.colorado.edu/index.php>).





**Figure 1.** Thin layer chromatography (TLC) plate run in Solvent C illustrating all major lichen secondary compounds in Colorado *Xanthoparmelia*. Each lane represents a different thallus sample. Note usnic acid is an example of a major compound, while norstictic acid is an example of a trace compound.

In addition to new field collections, we surveyed all collections of Colorado *Xanthoparmelia* housed at COLO: 277 specimens. Following study of these collections, annotations and chemical annotations were made. All measurements provided in the taxonomic treatment were taken from Colorado material only, using microscopy and imaging instrumentation and software described below. Structural measurements most commonly reflect two to four samples per structure per individual collection. The minimum and maximum measurement recorded yield the given range. Measurements and imaging were taken with a professional grade Nikon D7100 digital SLR equipped with a 105 mm 1:1 macrolens and ring flash, a professional grade Olympus SZX10 stereomicroscope, and Olympus BX51 compound epifluorescence microscope with Nomarski and *plan* optics, and a Retiga 200R firewire-enable imaging system.

A top priority of this study was to leave a clear platform for future researchers while maintaining the integrity of the COLO herbarium natural history collection. To do so, we conducted spot tests and Thin Layer Chromatography on new collections in addition to all existing collections housed at COLO. Even though several existing collections at COLO contained earlier TLC annotation slips, these collections were universally re-sampled for TLC study because of discrepancies among earlier researcher results. Care was taken to limit the amount of damage to any one specimen. Results from all new TLC assays were recorded via paper annotation slips inserted into specimen packets.

*Chemical Assays.* – Following standard protocols outlined in Brodo et al. (2001), we utilized K (potassium hydroxide), C (sodium hypochlorite), KC (potassium hydroxide followed by sodium hypochlorite), and P (*p*-phenyldiamine) spot tests to aid in the identification process of all examined specimens. Our analyses incorporated spot test results derived from prior testing of type material as provided via annotations on specimens, to help categorize all *Xanthoparmelia* specimens into chemical groups. We further conducted our own upper cortex and medullary spot tests on all material accessed by us during this



study; we focused on medulla spot tests due to the importance of this zone to *Xanthoparmelia* chemistry (Hale 1990; Nash and Elix 2004). Upper cortex UV tests were also performed, using a short-wave UV light following protocols in Brodo et al. (2001).

Thin Layer Chromatography (TLC; Elix 2014) was used to identify lichen metabolites in all specimens examined including all Colorado material, whether newly collected by us or already existing in COLO. For all TLC runs, an approximately 0.5 x 0.5 mm portion of the thallus (cortex + medulla) was placed into an individual ceramic well, avoiding reproductive structures that could contribute chemical anomalies (Hale 1955). Samples were soaked in acetone for approximately 1 minute and then spotted onto silica chromatography plates using a 10 µl pipette until a color ring depicting sufficient solute appeared on the plate. TLC was run using Solvent C as outlined in Culberson (1972). At the conclusion of the run, plates were examined under short-wave and long-wave UV light, where spot locations and colors visible under both wavelengths were marked. Plates were then run under water and examined while being warmed to detect fatty acids as hydrophobic spots. Finally, plates were “charred” to promote spot color development by treatment with 10% sulfuric acid followed by heat at 110°C (Culberson & Kristinsson 1970). Plates were scored for lichen compounds approximately one hour after charring to avoid any color fading and discoloration over time. Chemicals were identified following standardized Rf values provided in Elix (2014) (Figure 1).

*Species Concepts.* – Our approach for delimiting species of usnic acid-producing *Xanthoparmelia* in Colorado first relied upon study of type specimens coupled with protologue descriptions (where available). Following this, our concepts were informed by examination of morphological features, structural measurements (conidial measurements were not included in this study), and chemical assays (TLC, spot tests) of all specimens included in this study. Instances in which our collections and/or COLO herbarium collections were in conflict with information from species, protologues, or type material are noted below, and we have attempted to resolve such issues.

We here exclude *Xanthoparmelia taractica* and *X. hypopsila* from the present treatment of Colorado *Xanthoparmelia*. Although previously included in some North American treatments (Nash and Elix 2004; St. Clair 1999), upon exhaustive review of literature, we feel it is unlikely that these species occur in the United States (Hale 1990). Several treatments consider *Xanthoparmelia taractica* to occur only from Argentina (from where the species was described) to Mexico as well as Australasia (Elix et al. 1986; Hale 1990; Nash 1974). Regarding *X. hypopsila*, Hale (1988) considered the species to be strictly South American and South African, and considered North American material to best be treated under a separate name—*X. angustiphylla*. This taxonomy has since been followed in most subsequent North American keys (Brodo et al. 2001; Hale 1990), although some herbaria continue to file specimens from North America under *Xanthoparmelia hypopsila* (CNALH 2022). Further investigation that includes broad molecular sampling will be helpful to comprehensively assess relationships among these taxa.

*Map Generation.* – We used National Geographic TOPO! Version 3.4.2 (2003) to generate geographical coordinates for specimens of *Xanthoparmelia* from Colorado that were not previously georeferenced. These data together with existing georeferenced specimen data were then exported into ArcGIS Version 10.2 software, which was used to generate distribution maps.

## RESULTS AND DISCUSSION

After reviewing protologues, type materials, chemical assay results, and morphologies of all specimens included in this study, we recognize a total of 18 species of *Xanthoparmelia* occurring in the state of Colorado. Of these, nine reproduce primarily through asexual lichenized diaspores (*X. chlorochroa*, *X. conspersa*, *X. idahoensis*, *X. lavicola*, *X. mexicana*, *X. mougeotii*, *X. neochlorochroa*, *X. plittii*, *X. vagans*) and nine reproduce sexually (*X. coloradoensis*, *X. cumberlandia*, *X. lineola*, *X. monticola*, *X. novomexicana*, *X. psoromifera*, *X. stenophylla*, *X. subdecepiens*, *X. wyomingica*; Table 1). Four species are strictly vagrant (*Xanthoparmelia chlorochroa*, *X. idahoensis*, *X. neochlorochroa*, *X. vagans*), a term here taken as both a mode of reproduction and a distinct growth-habit found in Colorado *Xanthoparmelia* (as well as in other areas). While vagrant lichens utilize fragmentation as the primary mode of reproduction (Rosentreter 1993), the occurrence (albeit rare) of apothecia, conidia, and isidia suggests much is left to discover about reproductive biology of these species. Geographical maps depicting distributions of all 18 species found in Colorado are shown in Figure 2.



Taxon	Primary Reproduction			Primary Chemical Constituents				
	Asexual	Sexual	Vagrant	Fumar. Acid	Psoromic acid	Salazinic Acid	Stictic Acid	Atranorin
<i>X. chlorochroa</i>			x			x		
<i>X. coloradoensis</i>		x				x		
<i>X. conspersa</i>	x						x	
<i>X. cumberlandia</i>		x					x	
<i>X. idahoensis</i>			x			x		
<i>X. lavicola</i>	x				x			
<i>X. lineola</i>		x				x		
<i>X. mexicana</i>	x					x		
<i>X. monticola</i>		x		x				
<i>X. mougeotii</i>	x						x	
<i>X. neochlorochroa</i>			x					
<i>X. novomexicana</i>		x		x				
<i>X. plittii</i>	x						x	
<i>X. psoromifera</i>		x			x			
<i>X. stenophylla</i>		x				x		
<i>X. subdecipiens</i>		x						x
<i>X. vagans</i>			x				x	
<i>X. wyomingica</i>		x				x		

**Table 1.** Tabular comparison of recognized Colorado *Xanthoparmelia* species, including primary mode of reproduction, and primary chemical constituents in addition to usnic acid.

Five primary chemical groups were delimited to encompass the chemical diversity of all 18 taxa (Table 2; Figure 2). Chemical Group 1—the salazinic acid group—contains seven species; Chemical Group 2—the stictic acid group—contains five species; Chemical Group 3—the psoromic acid group—contains two species; Chemical Group 4—the fumarprotocetraric acid group—contains two species; and Chemical Group 5—the atranorin group—contains one species. All species were assigned to one and only one group except for *X. neochlorochroa*, which was not included in any group as it is chemically defined only by a lack of salazinic acid. All taxa additionally contained usnic acid, which is characteristic of the genus, as well as minor and/or trace amounts of additional chemical constituents (e.g., norstictic acid, consalazinic acid).

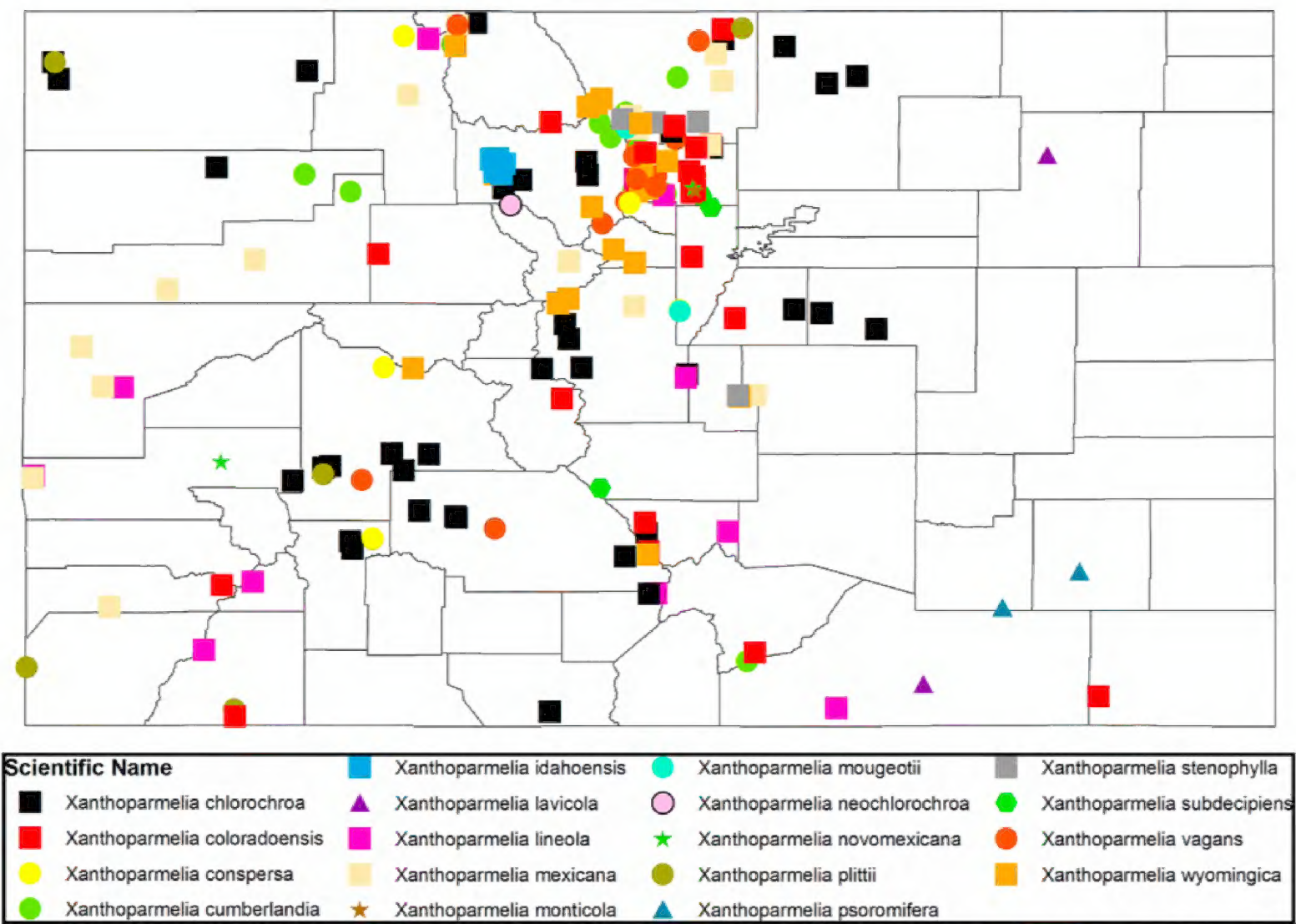
Chemical groups for the most part do not appear to be restricted to any specific habitat or elevation (however, exceptions exist; see Figure 2). Group 1 and Group 2 contain the greatest number of species (seven and five, respectively) and were also the most commonly occurring, as assessed by numbers of collections. Species in both groups occur throughout the state. Group 3 and Group 4 species were represented by the least number of collections in Colorado, yet these species have relatively broad geographical ranges. Group 5 species (i.e., *X. subdecipiens*) occurs only on the western slope. Whereas the COLO lichen collection houses excellent representation of Colorado *Xanthoparmelia*, distribution maps coupled with personal observations by the authors make clear that more field collections of *Xanthoparmelia* are needed, particularly in the eastern plains, to yield a more well-rounded understanding of distributions of species across the state.

After review of 367 Colorado specimens, one new synonym is proposed as part of this treatment: *X. arseneana* is placed in synonymy with *X. novomexicana*. This decision was made based on the similarities as deduced from protologue descriptions, type information, chemistry, and morphology. Priority was assigned using the earliest published name (McNeill et al. 2012; Turland et al. 2017). Additionally, *X. taractica* and *X. hypopsila* are excluded from the present treatment of Colorado.

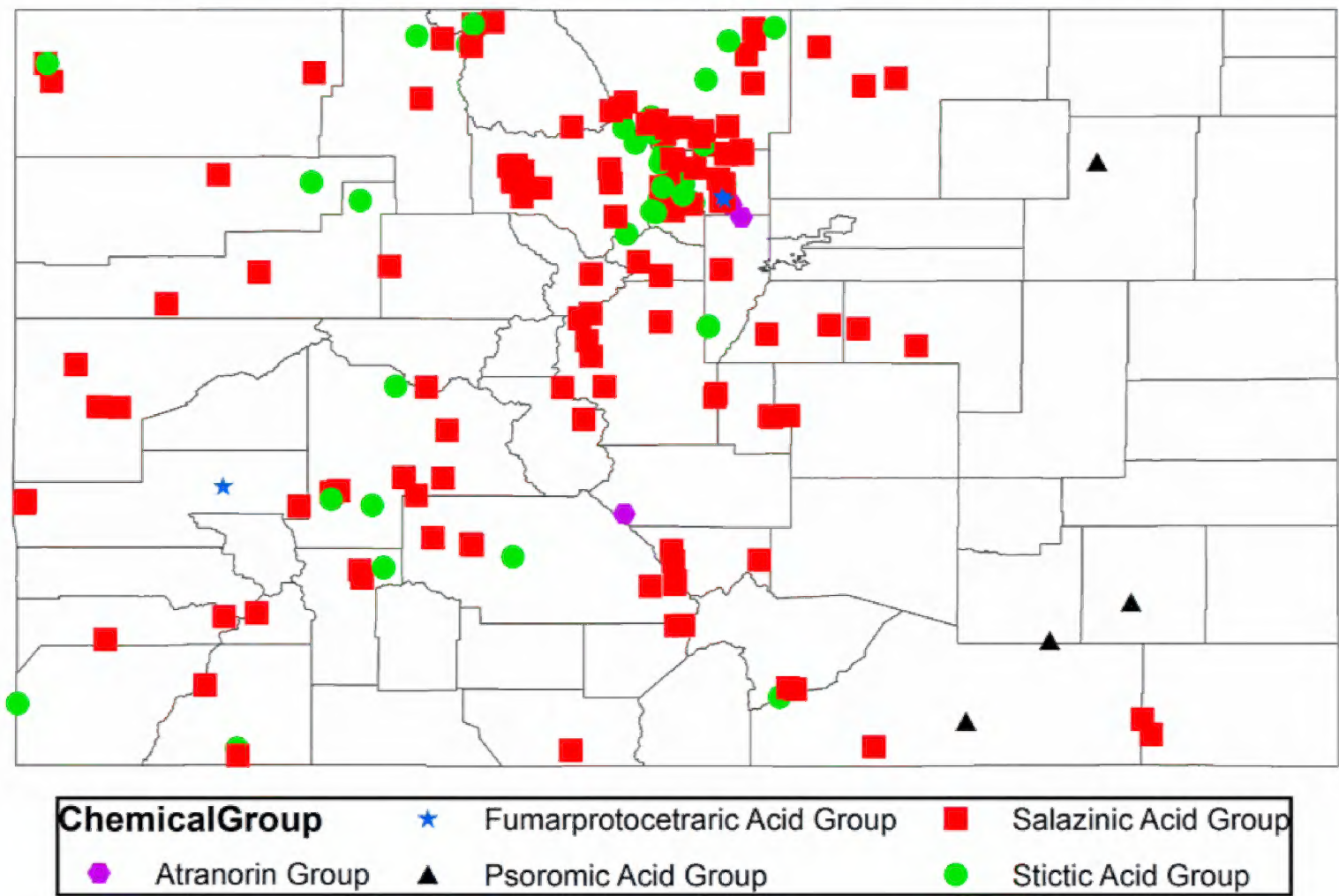
In addition, examination of these specimens suggests that TLC data along with information on reproductive mode and population niche/ecology together represent the most efficient means of species identification in this region. Spot test results, while useful, are much more susceptible to subjective determination and generally provide less robust information than TLC results. For example, both stictic and psoromic acid produce K+ yellow medulla spot tests, and both psoromic acid and norstictic acid react P+ yellow/golden (Elix 2014). Therefore, further investigation would be required for a reliable identification. Standardized R<sub>F</sub> values provide a much more reliable method of identifying even minor compounds of lichen-



# Species Distribution



# Chemical Group Distribution



**Figure 2.** Geographic distributions of species (top panel; see Table 1) and chemical groups (bottom panel, see Table 2) in Colorado, U.S.A. based on specimens examined for this study.

Group Number and Name	Taxon	Number of COLO vouchers
Group 1: Salazinic Acid Group	<i>X. chlorochroa</i>	45
Group 1: Salazinic Acid Group	<i>X. coloradoënsis</i>	117
Group 1: Salazinic Acid Group	<i>X. idahoensis</i>	10
Group 1: Salazinic Acid Group	<i>X. lineola</i>	49
Group 1: Salazinic Acid Group	<i>X. mexicana</i>	43
Group 1: Salazinic Acid Group	<i>X. stenophylla</i>	7
Group 1: Salazinic Acid Group	<i>X. wyomingica</i>	26
		Total: 297
Group 2: Stictic Acid Group	<i>X. conspersa</i>	2
Group 2: Stictic Acid Group	<i>X. cumberlandia</i>	16
Group 2: Stictic Acid Group	<i>X. mougeotii</i>	2
Group 2: Stictic Acid Group	<i>X. plittii</i>	19
Group 2: Stictic Acid Group	<i>X. vagans</i>	12
		Total: 51
Group 3: Psoromic Acid Group	<i>X. lavicola</i>	6
Group 3: Psoromic Acid Group	<i>X. psoromifera</i>	2
		Total: 8
Group 4: Fumarprotocetraric Acid Group	<i>X. monticola</i>	3
Group 4: Fumarprotocetraric Acid Group	<i>X. novomexicana</i>	3
		Total: 6
Group 5: Atranorin Group	<i>X. subdecepiens</i>	5
		Total: 5

**Table 2.** Number of vouchers for each species housed at COLO and organized by chemical group.

forming fungi. Future studies may seek to reconcile these delimitations, based primarily on morphology and chemistry, with sequence data from these collections.

Recent molecular evolutionary interest in *Xanthoparmelia* has sought to understand whether traditionally circumscribed species represent evolutionary lineages (i.e., whether species are reciprocally monophyletic; Amo de Paz et al. 2010a; Blanco et al. 2006; Leavitt 2010). In particular, Leavitt et al. (2011b) demonstrated that traditionally circumscribed species were not supported by molecular data. Their study included six species that occur in Colorado, and the authors found that these species belong to three polymorphic population clusters. Further studies by Leavitt et al. (2012) confirmed that chemical and morphological characteristics overestimate the number of species compared to species delimitation based on molecular data. Thus, previous notions of species delimitations across lichens and in particular within *Xanthoparmelia* may or may not be supported following incorporation of molecular phylogenomic data (Del Prado et al. 2010; Leavitt et al. 2011a, 2016) spanning all Colorado taxa. Recent techniques including RAD sequencing are demonstrating utility for resolving species relationships in lichens (Grewe et al. 2017; Leavitt et al. 2012) as well as in other lineages (Daniel & Tripp 2018; Tripp et al. 2017). Colorado *Xanthoparmelia* would be an excellent study system in which to further assess discrepancies between species groups defined based on morphological and chemical features versus those based on molecular phylogenomic methods.

#### TAXONOMIC TREATMENT





The following treatment is based on examination of type specimen digital loans, study of protologues, study of previously accessioned COLO material, and study of new material collected by the authors. All material in the specimens cited sections includes a unique identifier, which refers to barcodes affixed to COLO material. Spot test and TLC data listed under each species entry were taken from our observations of Colorado-only material. Characters that we found to be invariant across all species in Colorado, based on our material, are excluded from mention in the species accounts below. For example, thalli of all species and specimens studied here are considered foliose and contain a white medulla with a continuous algal layer.

# KEY TO THE SPECIES OF *XANTHOPARMELIA* IN COLORADO

1a. Thallus sorediate or isidiate .....	2
1b. Thallus not sorediate or isidiate .....	6
2a. Thallus sorediate .....	<i>X. mougeotii</i>
2b. Thallus isidiate .....	3
3a. Medulla: K+ red (salazinic, sometimes w/ norstictic) .....	<i>X. mexicana</i>
3b. Medulla: K+ yellow or orange (psoromic or stictic) .....	4
4a. Thallus with psoromic acid (K+ yellow) .....	<i>X. lavicola</i>
4b. Thallus with stictic acid (K+ yellow-orange) .....	5
5a. Lower surface black .....	<i>X. conspersa</i>
5b. Lower surface pale to dark brown .....	<i>X. plittii</i>
6a. Thallus vagrant, usually forming rosettes .....	7
6b. Thallus loosely to tightly adnate on rocks, pebbles, soil or bark .....	11
7a. Thallus with stictic acid (K+ yellow-orange) .....	<i>X. vagans</i>
7b. Medulla without stictic acid (K+ red, K+ yellow to red) .....	8
8a. Thallus without salazinic acid, with norstictic acid (K+ yellow to red) .....	<i>X. neochlorochroa</i>
8b. Thallus with salazinic acid (K+ red) .....	9
9a. Thallus with maculate upper surface .....	<i>X. idahoensis</i>
9b. Thallus lacking maculate upper surface .....	10
10a. Lobes dichotomously branched and deeply divided, apothecia not present .....	<i>X. chlorochroa</i>
10b. Lobes subdichotomously branched, apothecia infrequent to moderately common .....	<i>X. wyomingica</i>
11a. Thallus with salazinic acid (K+ red) .....	12
11b. Thallus without salazinic acid (K-, K+ yellow, or K+ yellow to orange) .....	15
12a. Thallus loosely adnate to substrate, lobes narrow (0.5–2 mm wide) .....	13
12b. Thallus tightly to loosely adnate to substrate; lobes wide (1–9 mm wide) .....	14
13a. Lobes separate to partially overlapping to convolute; growing on pebbles or moss or dirt; occurring at 3000 m+ elevation .....	<i>X. wyomingica</i>
13b. Lobes partially to fully overlapping, tightly shingled towards center of thallus; growing on rock; occurring at 2000-3000 m+ elevation .....	<i>X. stenophylla</i>
14a. Thallus tightly adnate to rock substrate; lobes closely appressed to substrate 1-3 mm wide .....	<i>X. lineola</i>
14b. Thallus loosely adnate to rock substrate; lobes typically lifting away from substrate 1-9 mm wide .....	<i>X. coloradoensis</i>
15a. Thallus with stictic acid (K+ yellow-orange) .....	<i>X. cumberlandia</i>
15b. Thallus without stictic acid (K- or K+ yellow) .....	16
16a. Thallus with psoromic acid (K+ yellow) .....	<i>X. psoromifera</i>
16b. Thallus without psoromic acid (K-) .....	17
17a. Thallus with atranorin (cortex) and protoconstipatic acids (medulla) (both major to trace) (K- and P-) .....	<i>X. subdeciapiens</i>
17b. Thallus with fumarprotocetraric acid (K-, P+ orange to red) .....	18
18a. Thallus adnate or tightly adnate on rock substrate .....	<i>X. novomexicana</i>
18b. Thallus loosely adnate to rock substrate .....	<i>X. monticola</i>



## ACCOUNTS OF THE SPECIES

*Xanthoparmelia chlorochroa* (Tuck.) Hale, Phytologia 28: 486. 1974.  $\equiv$  *Parmelia chlorochroa* Tuck., Proc. Amer. Acad. Arts 4: 383. 1860. **TYPE: U.S.A.** NORTH DAKOTA: Missouri River, 1859-1860, *F.V. Hayden s.n.* (FH[], lectotype [designated by Berry, Ann. Mo. Bot. Gard. 2: 70. 1941]; H [H9503765] [, MSC [MSC0122044] [, US [00068756] [, isoelectotypes).

### FIGURE 3.

**DESCRIPTION.** – **Thallus** vagrant. **Lobes** irregular; dichotomously branched and deeply divided, 3–8 mm wide; separate to subimbricate and strongly convolute; margins entire to crenate. **Upper surface** yellow-green, smooth, cracking and darkening towards older portions of thallus. **Lower surface** dark brown to black, shiny; rhizines black. **Apothecia** not seen. **Pycnidia** infrequent to occasional, black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); medulla: salazinic acid (major), consalazinic acid (minor), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red, C-, KC-, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia chlorochroa* is relatively common in the southern Rocky Mountains across an elevation range of approximately 1524–3048 m (5000–10000 ft), particularly in northern portions of Colorado (Figure 2) (CNALH 2016). It is a vagrant species commonly found on soil. The Navajo use it to create dyes for rugs, and it has also been known to poison livestock and elk (Brodo et al. 2001, Daily et al. 2008).

**NOTES.** – Ample confusion has existed regarding delimitation of vagrant *Xanthoparmelia* species worldwide. Lack of apothecia, presence of salazinic acid, and occurrence only in the Americas distinguish *X. chlorochroa* from other vagrant species found elsewhere in North America and beyond (Hale 1990, Rosentreter 1993). *Xanthoparmelia chlorochroa* is most frequently confused with *X. vagans* (compare Figures 2 and 19), which is similar morphologically but can be differentiated by the presence of stictic acid rather than salazinic acid (Hale 1990, and here confirmed).

TLC conducted on the isoelectotype at US (researcher unknown) also confirmed the presence of salazinic and usnic acids; however, at some unspecified but presumably later date (i.e., because of relative positional placements of TLC annotations on the packet), a different researcher (also unknown) added “stictic acid +” to the label, which we here presume to be an error. TLC conducted on all Coloradan material housed at COLO representative of this species recovered only salazinic and usnic acids as major compounds (norstictic was also commonly present in trace amounts).

*Additional specimens examined.* – **U.S.A. COLORADO.** ALAMOSA CO.: Great Sand Dunes National Monument, 5 mi S of headquarters, 10.vi.1954, *S. Shushan s.n.* (COLO-L-0047587). BOULDER CO.: Rabbit Mountain, E of Lyons, 4.x.1997, *W.A. Weber s.n.* (COLO-L-0047569); base of Steamboat Mountain, 2 mi NW of Lyons, 12.iii.1959, *W.A. Weber s.n.* (COLO-L-0047575). CONEJOS CO.: 5 mi W of Antonito, along roadside, 18.vii.1952, *W.A. Weber s.n.* (COLO-L-0047563); W bank of (and directly above) Conejos River, W of Plataro Reservoir, 37°18'33"N 106°35'54"W, 10850 ft, 4.vi.2013, *E.A. Tripp 4547* (COLO-L-0049977). CUSTER CO.: 8 mi W of Westcliffe, Alvarado Picnic Grounds, 13.vi.1952, *T.P. Maslin s.n.* (COLO-L-0047557). DOUGLAS CO.: Castlewood Canyon State Park, on the Arkansas Divide, 5 mi S of Franktown, vicinity of Bridge Canyon Overlook, 28.ix.2002, *W.A. Weber s.n.* (COLO-L-0047539). ELBERT CO., 14 mi E of Elbert, 13.v.1951, *W.A. Weber 5991* (COLO-L-0047545); ca. 7 mi NW of Elbert, 3.vii.1956, *R.P. Higgins s.n.* (COLO-L-0047551). GRAND CO.: ca. 4 mi SE of Kremmling, 1.ii.1972, *D.W. Reichert 262* (COLO-L-0047496); Shadow Mountain National Recreation Area, Table Mountain, 30.vii.1957, *J. Douglass s.n.* (COLO-L-0047521); between Parshall and Kremmling, 11.v.1952, *W.A. Weber 7323* (COLO-L-0047527); SE of road and 1.4 road mi E of Granby, 25.vii.1957, *J. Douglass s.n.* (COLO-L-0047533); Bureau of Land Management, ca. 2.2 air mi NE of Kremmling, S of Wolford Mountain in the vicinity of Cow Gulch, 30.viii.2014, *B. Elliot 16352* (COLO-L-0050857). GUNNISON CO.: 0.25 mi. S of US50, on Colorado Highway 114, 1.vi.1955, *J. Douglass s.n.* (COLO-L-0047484); 4 mi SW of



**Figure 3.** *Xanthoparmelia chlorochroa*, one of four vagrant *Xanthoparmelia* in Colorado. It frequently has dichotomous branching, lacks apothecia, and is probably the most common vagrant lichen found in the state.

Gunnison, 16.vii.1953, W.A. Weber *s.n.* (COLO-L-0047508); 4 mi SW of Gunnison, along roadside, 16.vii.1953, W.A. Weber *s.n.* (COLO-L-0047514); along Gunnison River Canyon, 2-5 mi W of Sapinero, 29.v.1952, W.A. Weber *s.n.* (COLO-L-0047520); 8.5 mi S of Gunnison, 14.viii.1952, M.L. Mattoon *s.n.* (COLO-L-0048363). HINSDALE CO.: Mesa Seco, near Slumgullion Pass, 24.vii.1964, W.A. Weber *s.n.* (COLO-L-0047472); above Slumgullion Pass, 16.viii.1951, G. Alexander *s.n.* (COLO-L-0047490). JACKSON CO.: 4.7 mi SE of Pearl, road to Big Creek Lake, 9.vii.1956, M.M. Douglass *s.n.* (COLO-L-0047478). LA PLATA CO.: just N of Bondad at junction of Florida and Animas Rivers, 12.vi.1955, S. Shushan *s.n.* (COLO-L-0047460). LARIMER CO.: 12 mi NW of Wellington, 19.iv.1952, W.A. Weber *s.n.* (COLO-L-0047454). MOFFAT CO.: Douglas Mountain, triangulation point above the Copper Mine, 29.vii.1960, M. MacLeod 147 (COLO-L-0047466); N end of Dinosaur National Monument, at entrance of Green River into the Canyon of Lodore, ca. 1 mi S of Browns Park, 29.vii.1962, S. Flowers *s.n.* (COLO-L-0047519). MONTROSE CO.: above Cimarron Creek, 5 mi S of Cimarron, 8.viii.1954, S. Shushan *s.n.* (COLO-L-0047483). PARK CO.: 4 mi S of Fairplay, 6.vi.1952, W.A. Weber *s.n.* (COLO-L-0047471); near N end of Antero Reservoir, 29.v.1955, J. Douglass *s.n.* (COLO-L-0047489); Nordamerika, S of Fairplay, 6.vii.1952, S. Shushan *s.n.* (COLO-L-0047507); 3 mi W of Florissant, just over Teller-Park County line, 12.iv.1954, S. Shushan *s.n.* (COLO-L-0047513); Hoosier Pass campground, 4.vii.1954, S. Shushan *s.n.* (COLO-L-0047477); S/W bank of South Fork of the South Platte River, along County Road 22, E of Weston Pass, 39.083795 -106.139743, 10313 ft, 27.vi.2015, E.A. Tripp 5600 (COLO-L-0051289). RIO BLANCO CO.: valley of Strawberry Creek. 7 mi NW of Meeker, 10.v.1952, W.A. Weber 7380 (COLO-L-0047501). SAGUACHE CO.: Great Sand Dunes National Park, Mineral King Trail off Brook Trout Rd., Grats Parcel of Baca Grande Subdivision near Crestone, W base of Sangre de Cristo Range; 27.i.2001, J. Erdman 44 (COLO-L-0047453); 0.6 mi from Old Agency Ranger Station on Los Pinos Pass Rd., 1.vi.1955, J. Douglass *s.n.* (COLO-L-0047459); Cochetopa Park, just S of summit of Cochetopa Pass, 10.viii.1955, W.A. Weber *s.n.* (COLO-L-0047465); 3 mi NW of Cochetopa Pass on Colorado Highway 114, 1.vi.1955, J. Douglass *s.n.* (COLO-L-0047495). WELD CO.: 7 mi N of Nunn on Highway 85, 8.iv.1955, J. Douglass *s.n.* (COLO-L-0047506); Pawnee National Grassland, 20 km ENE of Ault along Rte. 12, 9.viii.1984, T.H. Nash III 25761 (COLO-L-0047512); Pawnee National Grassland, 20 mi E of Ault, 18.ii.1994, J. K. Nelson 1670 (COLO-L-0047518).



*Xanthoparmelia coloradoensis* (Gyel.) Hale, Mycotaxon 33: 402. 1988.  $\equiv$  *Parmelia ioannis-simae* var. *coloradoensis* Gyel., Repert. Spec. Nov. Regni Veg. 31: 287. 1931. **TYPE:** U.S.A. COLORADO: Caribou (“Cariberu”), 3109 m. (10200 ft) elevation, 18.ii.1916, I.W. Clokey 14 (US 00344632 [image!], lectotype (designated by Hale 1990: 87); BP[image!], isolectotype).

**FIGURE 4.**

**DESCRIPTION.** – **Thallus** adnate to loosely adnate; saxicolous. **Lobes** sublinear; moderately divided, 1–9 mm wide; minimally to moderately imbricate; margins browning towards tips; apices usually crenate. **Upper surface** yellow-green, smooth, cracking and darkening towards older portions of thallus. **Lower surface** pale brown; rhizines brown, frequent. **Apothecia** frequent, sessile, disks light to dark brown, margins subconvex. **Ascospores** ellipsoid, non-septate, colorless,  $6\text{--}7 \times 4\text{--}5 \mu\text{m}$ . **Pycnidia** frequent, black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic (minor), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ dark orange to red, C-, KC-, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia coloradoensis* is primarily found within the southern Rocky Mountains but also occurs in mountainous areas of Arizona, New Mexico, Baja California del Sur, and in California coastal sage communities (Hale 1990, Nash 2002). The species grows in an extremely broad diversity of habitats in Colorado (Figure 2) ranging from sagebrush plains to coniferous forests.

**NOTES.** – *Xanthoparmelia coloradoensis* is member to the largest chemical group in Colorado, which includes *X. lineola*, *X. chlorochroa*, and *X. wyomingica* (see Figure 2). All contain salazinic, consalazinic, norstictic, and usnic acids. It can be easy to confuse *X. coloradoensis*, *X. lineola*, and *X. wyomingica* at first glance. Variation between the three is primarily related to lobe morphology: *X. lineola* (Figure 9) is tightly adnate (to rocks) with narrow lobes while *X. wyomingica* (Figure 20) is extremely loosely adnate with convoluted lobes. *X. coloradoensis* falls in the middle of this spectrum, having broader lobes than those of *X. lineola* but being moderately to loosely adnate to its rocky substrate (Hale 1990).

Spot tests conducted by V. Gyelnik annotated on the isolectotype were somewhat contradictory (“Thallus P-, Medulla: K+ not red, (possibly) KC+ red, C-, P+ yellow”, verbatim from Gylenik’s annotation label). However, the TLC results performed by Hale in 1989 on the isolectotype are compatible with the spot test results found consistently across all Colorado material, which were determined by the authors to be accurate.

*Additional specimens examined.* – **U.S.A. COLORADO.** BACA CO.: vicinity of Dodge Ranch, SW of Uteyville, 4500 ft, 4.ix.1955, S. Shushan s.n. (COLO-L-0047975). BOULDER CO.: W side of Steamboat Mt., 3 mi. NW of Lyons, ca. 5600 ft, 7.ii.1954, W.A. Weber s.n. (COLO-L-0048103); first Flatiron just above mouth of Gregory Canyon, 1800 m.s.m., 6.vii.1976, W.A. Weber s.n. (COLO-L-00448011); Rocky Mountain National Park, Longs Peak Valley, 2774 m, 14.ix.1932, W. Kiener 80 (COLO-L-0047763), 10.viii.1935, W. Kiener 3042 (COLO-L-0047769); Lytle Formation, Dakota Group, ca. 4 mi N of Boulder, T1N, R71W, SEC1, 6100 ft, 1.viii.1959, R.A. Anderson s.n. (COLO-L- 0048077); NW slope of Green Mountain, SW of Boulder, 2286 m, 2.ii.1952, S. Shushan s.n. (COLO-L-0047731); White Rocks, 8 mi NE of Boulder on N side of Boulder Creek, 30.xi.1975, W.A. Weber s.n. (COLO-L-0048060); Colorado Front Range W of Boulder, junction of Peak-to-Peak Highway and Gold Hill Rd., 13.vi.1998, 2743 m, W.A. Weber s.n. (COLO-L-0047586); White Rocks Nature Preserve, 40.05335 -105.15531, 569 m, 22.vii.2014, E.A. Tripp 4840 (COLO-L-0050574); White Rocks Nature Preserve, 40.05352 -105.15909, 1580 m, 6.viii.2014, E.A. Tripp 4855 (COLO-L-0050587); 1 mile NE of Gold Hill along Lefthand Creek, 2256 m, 4.vi.1967, C.M. Wetmore 16082 (COLO-L-0047780); City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.145179° -105.265515°, 5568 ft, 19.vi.2015, V. Diaz 2 (COLO-L-0055900), 40.144591°, -105.26385°, 5550 ft, 19.vi.2015, V. Diaz 7 (COLO-L-0055882); City of Boulder Open Space, Austin-Russell Property, along Blue Ski Jump and Bell/ Baird Trails, approx. 0.5 mi S of Baseline Rd., 39.992928° -105.289204°, 5821 ft, 26.vi.2015, V. Diaz 9 (COLO-L-0055821), 39.995266° -105.287005°, 5821 ft, 26.vi.2015, V. Diaz 14 (COLO-L-0055881), 39.992928°, -105.289204°, 5821 ft, 26.vi.2015, V. Diaz 19 (COLO-L-0055816); City of Boulder Open Space, Austin-Russell Property, along

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**Figure 4.** *Xanthoparmelia coloradoensis* is one of the many salazinic acid-containing species in Colorado. Note the looser adnation to the rock and slightly more foliose appearance compared to *X. lineola*.

Chataqua Trail, approx. 0.5 mi S of Baseline Rd., 39.995266° -105.287005°, 5821 ft, 26.vi.2015, V. Diaz 10 (COLO-L-0055822); City of Boulder Open Space, Circle of Friends Property, along Sunshine Canyon Trail on S side of Sunshine Canyon Drive, 40.022072° -105.300673°, 5587 ft, 26.vi.2015, V. Diaz 13 (COLO-L-0055812), V. Diaz 18 (COLO-L-0055871); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.45 mi from trailhead, 40.026184° -105.30068°, 5931 ft, 10.vii.2015, V. Diaz 45 (COLO-L-0055876), 40.025893° -105.30021°, 5931 ft, 10.vii.2015, V. Diaz 48 (COLO-L-0055889); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.5 mi from trailhead, 40.027523° -105.302771°, 5557 ft, 10.vii.2015, V. Diaz 46 (COLO-L-0055798), V. Diaz 59 (COLO-L-0055826); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.4 mi from trailhead, 40.025633° -105.300146°, 5931 ft, 10.vii.2015, V. Diaz 50 (COLO-L-0055796), V. Diaz 57 (COLO-L-0055824); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail, approx. 0.3 mi from trailhead, 40.022115°, -105.2982°, 5931 ft, 10.vii.2015, V. Diaz 58 (COLO-L-0055825); City of Boulder Open Space, Schneider Property, approx. 0.5 mi W of N Foothills Parkway/US 36, 40.079388° -105.290551°, 5328 ft, 26.vi.2015, V. Diaz 17 (COLO-L-0055815), 40.079394°, -105.289748°, 5328 ft, 26.vi.2015, V. Diaz 21 (COLO-L-0055887); 40.079628°, -105.289906°, 5328 ft, 26.vi.2015, V. Diaz 26 (COLO-L-0055845); City of Boulder Open Space, Schneider Property, approx. 1.5 mi W of N Foothills Parkway/US 36, 40.079681° -105.294781°, 5328 ft, 26.vi.2015, V. Diaz 27 (COLO-L-0055883), 40.079779° -105.295412°, 5328 ft, 26.vi.2015, V. Diaz 28 (COLO-L-0055790); City of Boulder Open Space, Bergheim-Wood Property, along Flatirons Loop Trail, approx. 75 ft W of intersection w/ Bluebell Trail, 39.991142°, -105.287716°, 6148 ft, 29.vi.2015, V. Diaz 31 (COLO-L-0055835); City of Boulder Open Space, Bergheim-Wood Property, along Woods Quarry Trail, approx. 280 ft W from intersection w/ Mesa Trail, 39.987509° -105.286632°, 6382 ft, 29.vi.2015, V. Diaz 32 (COLO-L-0055836); City of Boulder Open Space, Bergheim-Wood Property, along Bluebell-Baird Trail, approx. 270 ft N of intersection w/ Flatirons Loop Trail, 39.991763° -105.287501°, 6123 ft, 29.vi.2015, V. Diaz 34 (COLO-L-0055838); City of Boulder Open Space, Bergheim-Wood Property, along Flatirons Loop Trail, approx. 75 ft W of intersection w/ Bluebell Trail,



39.991142° -105.287716°, 6148 ft, 29.vi.2015, *V. Diaz* 35 (COLO-L-0055789); City of Boulder Open Space, Bergheim-Wood Property, along Flatirons Loop Trail, just S of intersection w/ Bluebell-Baird Trail, 39.992425° -105.288971°, 6200 ft, 29.vi.2015, *V. Diaz* 36 (COLO-L-0055872), *V. Diaz* 40 (COLO-L-0055894); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 360 ft NW of McClintock Upper Trail, 39.990579° -105.286879°, 6148 ft, 29.vi.2015, *V. Diaz* 37 (COLO-L-0055873); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 350 ft N of intersection w/ Woods Quarry Trail, 39.986494° -105.286149°, 6208 ft, 29.vi.2015, *V. Diaz* 38 (COLO-L-0055893), *V. Diaz* 39 (COLO-L-0055788); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 75 ft S of McClintock Upper Trail, 39.990115° -105.285999°, 6117 ft, 29.vi.2015, *V. Diaz* 41 (COLO-L-0055787), *V. Diaz* 42 (COLO-L-0055839); City of Boulder Open Space, Hogan Brothers Property, approx. 250 ft E of S Cherryvale Rd., 39.962469° -105.211265°, 5546 ft, 17.vii.2015, *V. Diaz* 60 (COLO-L-0055827); City of Boulder Open Space, Hogan Brothers Property, approx. 210 ft E of S Cherryvale Rd., 39.962783° -105.211411°, 5546 ft, 17.vii.2015, *V. Diaz* 61 (COLO-L-0055878), *V. Diaz* 64 (COLO-L-0055874); City of Boulder Open Space, Hogan Brothers Property, approx. 500 ft E of S Cherryvale Rd., 39.962132° -105.211481°, 5547 ft, 17.vii.2015, *V. Diaz* 63 (COLO-L-0055793); City of Boulder Open Space, Van Vleet Property, just W of S. Cherryvale Rd. and just S of Marshallville Ditch, 39.974252° -105.213577°, 5463 ft, 17.vii.2015, *V. Diaz* 66 (COLO-L-0055805); City of Boulder Open Space, Jewel Mountain Property, approx. 50 ft E of Plainview Rd. and approx. 400 ft S of Coal Creek, 39.877702° -105.268981°, 6464 ft, 24.vii.2015, *V. Diaz* 69 (COLO-L-005580); City of Boulder Open Space, Fraiser Farms Property, at the intersection of Mesa and Upper Big Bluestem Trails, 39.953578° -105.279707°, 6092 ft, 14.viii.2015, *V. Diaz* 74 (COLO-L-0055886); City of Boulder Open Space, East Rudd Property, along Davidson Ditch just S of Marshall Valley Trail, 39.954074° -105.21845°, 5608 ft, 20.viii.2015, *V. Diaz* 76 (COLO-L-0055800); City of Boulder Open Space, Flatirons Vista Property, approx. 50 ft S of Prairie Vista Trail, 39.922773° -105.24055°, 6054 ft, 27.viii.2015, *V. Diaz* 77 (COLO-L-0055801); City of Boulder Open Space, Hedgecock Property, just S of S. Boulder Creek W. Trail, approx. 460 ft E of intersection w/ Mesa Trail, 39.94552° -105.261629°, 5736 ft, 12.x.2015, *V. Diaz* 81 (COLO-L-0055804). CHAFFEE CO.: 5 mi E of Buena Vista, 8500 ft, 6.vi.1952, *S. Shushan s.n.* (COLO-L-0048017). CUSTER CO.: 8 mi W of Westcliffe, 8000 ft, 13.vi.1952, *T.P. Maslin s.n.* (COLO-L-0048096). DOLORES CO.: 10.2 road mi NE of Rico Liza Rd. Head Pass, 9800 ft, 16.vi.1954, *J. Douglass s.n.* (COLO-L-0048040). DOUGLAS CO.: Jackson Gulch, 7800 ft, 28.vi.1952, *S. Shushan s.n.* (COLO-L-0048053). EAGLE CO.: benches of Eagle River 6 mi W of Gypsum, 6100 ft, 14.v.1954, *W.A. Weber s.n.* (COLO-L-0048121). HINSDALE CO.: San Juan Mountains, Cataract Lake Basin, flat alpine plains of unnamed mountain, off trail and above (to E of) Cataract Lake, 37.850995 -107.421704, 13,000 ft, 11.vi.2015, *E.A. Tripp* 5688 (COLO-L-0051196), *E.A. Tripp* 5682 (COLO-L-0051190). HUERFANO CO.: E of Spanish Peak, S of La Veta, 11500 ft, 17.viii.1955, *S. Shushan s.n.* (COLO-L-0048048). LAKE CO.: Mosquito Range, near summit of unnamed peak between Ptarmigan Peak and Horseshoe Couliour, 39.159492 -106.176807, 13,700 ft, 28.vi.2015, *E.A. Tripp* 5583 (COLO-L-0051275), *E.A. Tripp* 5592 (COLO-L-0051284). LARIMER CO.: Estes Park, 9 mi SE of; or 14 mi NW of Lyons, off Denver Highway, 7500 ft, 26.vii.1949, *W. Kiener* 24767 (COLO-L-0047629); 19 mi N of LaPorte, 1981m, 29.iv.1954, *S. Shushan s.n.* (COLO-L-0047793); 11 mi E of Trail Ridge Campground, 8500 ft, 29.vii.1951, *S. Shushan s.n.* (COLO-L-0048050). MESA CO.: ca. 7 mi. SW of Whitewater, above East Creek N of Gibbler Gulch, 1.vi.1973, *W.A. Weber s.n.* (COLO-L-0047745). MONTROSE CO.: 4 mi W of Montrose on Colorado highway 90, 1585 m, 3.ix.1971, *G.K. Arp* 1722 (COLO-L-0047885). PARK CO.: 3 mi W of Florissant, just over Teller-Park County line, 2469 m, 12.iv.1954, *S. Shushan s.n.* (COLO-L-0047757). Buffalo Peaks, top of saddle separating Four Mile Creek and Buffalo Meadow drainages, 2.viii.1991, 3475 m, *R.E. Abbot* 275 (COLO-L-0047592).

*Xanthoparmelia conspersa* (Ehrh. ex Ach.) Hale, Phytologia 28: 485. 1974.  $\equiv$  *Lichen conspersus* Ehrh. ex Ach., Lichenogr. Suec. Prodr. (Linköping) p. 118. 1798. **TYPE: SWEDEN:** without location or collector, (H-ACH [H9502091] [image!], lectotype designated by Gyelnik (1930: 31).

**FIGURE 5.**

**DESCRIPTION.** – **Thallus** adnate to loosely adnate; saxicolous. **Lobes** irregular; moderately divided, 1–4 mm wide; separate to moderately imbricate, at times subconvolute; margins browning, apices usually crenate. **Upper surface** yellow-green, smooth, cracking and darkening towards older portions of thallus. **Lower surface** black, shiny; rhizines black with black rhizines, occurring frequently. **Isidia** at first globose, then becoming cylindrical and branching moderately; at times black or brown on tips. **Apothecia** infrequent



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**Figure 5.** *Xanthoparmelia conspersa* is one of the isidiate species in Colorado. The lobe width (1–4 mm) and moderate adnation to the substrate are characteristic of what many think of as classic *Xanthoparmelia*.

to common, sessile; disks light to dark brown; margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless,  $6-7 \times 5 \mu\text{m}$ . **Pycnidia** occurring frequently black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ yellow-orange, C-, KC-, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia conspersa* is very common in the U.S.A., particularly in the eastern U.S. (Hale 1990, Nash 1974). In Colorado, it can be found primarily in northern portions of the state at elevations ranging from 1829–3200 m (6000–10500 ft) in a wide range of habitats, from disturbed cattle ranches to undisturbed subalpine montane regions (Figure 2).

**NOTES.** – *Xanthoparmelia conspersa* is the type species of the genus and the namesake of the *X. conspersa* group, which comprises *X. conspersa*, *X. tinctina* (Mah. & Gillet) Hale, *X. piedmontensis* (Hale) Hale, *X. plittii*, *X. dierythra*, *X. mexicana*, and *X. subramigera* (Gyeln.) Hale. This group has been the focus of recent studies investigating many areas of lichenology including population diversity, secondary metabolites, and air pollution (Armstrong 2017, Matteucci et al. 2017, Puy-Alquiza et al. 2017). The species in this group are characterized by presence of isidia, black to light brown lower surfaces, and presence of one of four diagnostic acids: stictic, norstictic, salazinic, and fumarprotocetraric. Of these traits, *X. conspersa* has isidia, stictic acid, and a black lower surface.

Despite its importance as a widespread and abundant species as well as its status as type of the genus, there has been extensive discrepancy as to the delimitation of *Xanthoparmelia conspersa* historically. Over the last two centuries, that this species is predominately isidiate has been propagated throughout the literature (Hale 1990, Nash and Elix 2004). However, in the protologue written by Jakob Ehrhart (and validated by Acharius), there is clear mention of apothecia on the material he was examined. There is no mention of isidia. In addition, and to make matters more confusing, there are two specimens in H-ACH on the same sheet that have both been annotated as the lectotype. Gyelnik (1930) inadvertently lectotypified one





**Figure 6.** *Xanthoparmelia cumberlandia* is one of the most prominent fertile, stictic acid-containing species in Colorado. It is easily separated from the substrate, which is characteristic of this species.

of the two specimens by noting that the top (abundantly isidiate) specimen was representative of *Parmelia isidiata* (Anzi.) Gyl. and the bottom (abundantly fertile) representative of *X. conspersa* (Hale and Kurokawa 1964, Hale 1990). Thus, the protologue and Gyelnik's actions seem to suggest that *X. conspersa* is, in fact, a fertile species. However, upon close examination of the physical specimen by T. Ahti and J.C. Lendemer (as requested by us in preparation for this study), we confirm that both the top and bottom specimens bear isidia, thus confirming the long-held concept that *X. conspersa* is indeed isidiate. Hale's later attempt (1964; also see Hale 1990) to re-lectotypify the name with a different specimen (the top rather than the bottom) should be considered as superfluous given that Gyelnik's original lectotypification is not in conflict with the protologue.

*Additional specimens examined.* – **U.S.A. COLORADO.** HINSDALE CO.: Cebolla Creek Campground, 9400 ft, 29.vii.1964, W.A. Weber *s.n.* (COLO-L-0048000). GILPIN CO.: road to Corona, 11.vii.1918, C.C. Plitt *s.n.* (COLO-L-0048277). GUNNISON CO.: along East River just below Emerald Lake, 3200 m, 13.vii.1955, W.A. Weber *s.n.* (COLO-L-0047701). JEFFERSON CO.: Bancroft property, The Castle, just N of Wellington Lake, 9.vii.1976, W.A. Weber *s.n.* (COLO-L-0047803). ROUTT CO.: Slopes of Hahn's Peak, 3 mi E of Columbine, 2743 m, 22.vi.1965, W.A. Weber *s.n.* (COLO-L-0047671).

*Xanthoparmelia cumberlandia* (Gyl.) Hale, Phytologia 28: 486. 1974.  $\equiv$  *Parmelia subconspersa* var. *cumberlandia* Gyl. Repert. Spec. Nov. Regni Veg. 36: 164. 1934. **TYPE:** U.S.A. MAINE: Cumberland, vii.1907, E.B. Chamberlain *s.n.* (BP [image!]!, lectotype designated by Hale 1990: 98).

#### FIGURE 6.

**DESCRIPTION.** – **Thallus** adnate to loosely adnate; saxicolous. **Lobes** irregular, 1–8 mm wide, separate to subimbricate, flat to convolute; margins black at tips, apices mostly crenate. **Upper surface** yellow-green; epruinose, smooth, areolate and darkening towards older portions of thallus. **Lower surface** pale brown; rhizines brown to black. **Apothecia** infrequent to common, sessile; disks light to dark brown; margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless, 6–7 x 4–5  $\mu$ m. **Pycnidia** common, black, sunken below upper cortex.



CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor), constipatic acid (trace). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ yellow to orange, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia cumberlandia* is very common across many portions of North America (Hale 1990; Nash and Elix 2004; Pringle et al. 2003). It however seems to be relatively uncommon in Colorado, where it occurs primarily in the southern Rocky Mountains in coniferous forests to alpine tundra over approximately 2286 m elevation (7500 ft).

NOTES. – *Xanthoparmelia cumberlandia* is generally considered to be the non-isidiate counterpart of the asexual species *X. plittii* (Figure 15) in that the two share chemistry and other (non-reproductive) morphological features. However, in the protologue for *X. cumberlandia*, Gyelnik clearly stated that the type specimen has a black underside., this correlates with examination of an image of the lectotype by the authors. (the holotype was presumably destroyed in Bouly de Lesdain's herbarium in Dunkirk, France during WWII). This is problematic because current usage of the name includes solely specimens with pale undersides. It may be that an alternative, existing name for specimens that otherwise fit the above concept of *X. cumberlandia* but have pale undersides is ultimately needed. If a name is not found, a new name for a fertile, stictic acid-containing species with a pale underside that occurs in North America may be warranted. Further study in comparison to specimens annotated as *X. plittii* (Figure 15) is also needed because the two taxa share numerous features.

*Additional specimens examined.* – U.S.A. COLORADO. BOULDER CO.: just NW of Boulder, 1829 m, 6.iv.1962, W.A. Weber s.n. (COLO-L-0047517); Upper Gregory Canyon, ca. 1 mi W of Boulder and 1 mi N of Green Mountain summit, 1940-1980 m, 10.x.1974, G. Kunkel s.n. (COLO-L-0047897); 5 mi NW of Eldora on trail from 4th of July Canyon, to Arapahoe Glacier, 3048-3353 m, 20.viii.1957, S. Shushan s.n. (COLO-L-0047666); Boulder Canyon near Tungsten, 12 mi W of Boulder, 2438 m, 29.iv.1959, S. Shushan s.n. (COLO-L-0047672); Rocky Mountain National Park, Longs Peak, 3368 m, 17.ix.1933, W. Kiener 507 (COLO-L-0047683); City of Boulder Open Space, Austin-Russell Property, along Blue Ski Jump and Bell/ Baird Trails, approx. 0.5 mi S of Baseline Rd., in gravelly area among conifer trees, saxicolous, 39.996228°, -105.289193°, 6095 ft, 26.vi.2015, V. Diaz 12 (COLO-L-0055891). CUSTER CO.: South Colony Creek basin, 37.98333 -105.50000, 3566 m, 8.vii.1941, W. Kiener 10281 (COLO-L-0047719). EL PASO CO.: Golf Links, 2600 m, 6.ix.1904, F. E. Clements s.n. (COLO-L-0047695). GARFIELD CO.: White River National Forest, trail from Trappers Lake to Coffin Lake, ca. 30 mi E of Bufo Rd., 2957 m, 13.vii.1957, S. Shushan s.n. (COLO-L-0047725). GRAND CO.: near base of south slope of Jackstraw Mountain, 1.5 mi W of Timber Lake, 3219-3292 m, 4.vii.1962, R.A. Anderson 2330 (COLO-L-0047707); Tonahutu Creek Trail, 1 mi E of Granite Falls, base of Snowdrift Peak, 3078-3139 m, 27.vii.1962, R.A. Anderson 2422 (COLO-L-0047713). GUNNISON CO.: trail along Copper Creek to summit of Conundrum Pass, ca. 10 mi NE of Gothic, 10500 ft, 5.viii.1955, W.A. Weber s.n. (COLO-L- 0048074). HUERFANO CO.: Apishapa Pass. 10.vi.1960, S. Shushan s.n. (COLO-L-0047499). JEFFERSON CO.: lower slopes of spurs of "The Castle," Bancroft property NW of Willington Lake, 22.vi.1976, W.A. Weber s.n. (COLO-L-0048301). RIO BLANCO CO.: White River National Forest, Lost Creek Campground, 10 mi NW of Bufo Rd., 2286 m, 12.vii.1957, S. Shushan s.n. (COLO-L-0047689); S ridge of Mt. Zirkel, Park Range, E of Slavonia above Gold Creek, 3444 m, 28.vii.1956, S. Shushan s.n. (COLO-L-0047677).

*Xanthoparmelia idahoensis* Hale, Mycotaxon 34: 547. 1989. **TYPE:** U.S.A. IDAHO. LEMHI CO.: SE of Salmon, T 21N, R 22E, Sec 28, sites nearly barren of vascular vegetation and surrounded by shade scale *Artemisia confertifolia*, 1219 m. (4000 ft), 4.vi.1986, on calcareous laucustrine ash soil, R. Rosentreter 3828 (US [00075673] [image!], holotype; SRP [00075673] [image], isotype).

#### FIGURE 7.

DESCRIPTION. – **Thallus** vagrant. **Lobes** sublinear, dichotomously branched, deeply divided 1–4 mm wide, sometimes black at apices; margins subcrenate. **Upper surface** yellow-green, strongly maculate, cracking and darkening towards older portions of thallus. **Lower surface** pale yellow to brown, shiny; rhizines infrequent. **Apothecia** not seen. **Pycnidia** not seen.



L-96508



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**Figure 7.** *Xanthoparmelia idahoensis* is characterized by its maculate surface (cracks in the upper cortex and photobiont layer that expose the white medulla below) with maculae visible under a dissecting microscope.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic acid (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red, C-, KC-, P+ orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia idahoensis* is currently only known to occur in very limited barren (“badlands”) portions of Colorado and Idaho, U.S.A., and Saskatchewan, Canada, and is very rare (Goffinet et al. 2001, Rosentreter 1993). In Colorado, the COLO Herbarium only documents the species from Grand County, at an elevation of approximately 2377 m (7800 ft) (Figure 2). *Xanthoparmelia idahoensis* grows in cold, arid areas with low abundances of vascular vegetation (Goffinet et al. 2001). This species is considered by the Idaho Department of Fish and Game to be critically imperiled within the state of Idaho (Moseley et al. 1974).

NOTES. – *Xanthoparmelia idahoensis* greatly resembles *X. chlorochroa* (Figure 3) in chemistry, morphology, and habit. One must however examine the upper cortex to find the maculate surface of the former (Figure 7), which distinguishes these two species.

Upon studying the COLO specimens of *Xanthoparmelia idahoensis*, we encountered slight variation in spot tests (K+ yellow or orange instead of red); we also detected two unknown accessory compounds during TLC in two of the specimens. One occurred at an  $R_F$  value of approximately 35–40, turning brown with a blue halo under acid and heat. The other compound resolved at an  $R_F$  value of approximately 60, also turning brown with a blue halo under heat. Because of uncertain taxonomic status of these two specimens, they are excluded from this treatment but are under further study.

*Additional specimens examined.* – U.S.A. COLORADO. GRAND CO.: T2N, R81W, S26, 40°06'N 106°25'W, 2300 m, 17.vi.1995, R. Rosentreter 9339 (COLO-L-0051162); approx. 8.2 air mi N of Kremmling on the E side of Hwy 9, 7630 ft, 31.viii.2014, B. Elliot 16364 (COLO-L-0050864); approx. 8.3 air miles N of Kremmling, E of Wolford Mountain Reservoir near CR 25, 40.17763 -106.39828, 2338 m, 29.viii.2014, B. Elliot 16342 (COLO-L-0050876); approx. 7.7 air mi N of Kremmling, E of Wolford Mountain Reservoir



L-59093



**Figure 8.** *Xanthoparmelia lavicola* is the only isidiate species in Colorado with psoromic acid. Chemistry is required to differentiate *X. lavicola* and other asexual *Xanthoparmelia* species in Colorado.

near CR 25, 40.16910 -106.39707, 2335 m, 29.viii.2014, *B. Elliot 16345* (COLO-L-0050851); approx. 6.2 air mi NE of Kremmling, E of Wolford Mountain Reservoir near CR 25, 40.14727 -106.36011, 2414 m, 30.viii.2014, *B. Elliot 16348* (COLO-L-0050853); approx. 2.2 air mi NE of Kremmling, S of Wolford Mountain in the vicinity of Cow Gulch, near wooden power line, 40.09117 -106.37737, 2344 m, *B. Elliot 16351* (COLO-L-0050856); approx. 8.2 air mi N of Kremmling on the E side of Hwy 9, 40.17088 -106.43558, 2323 m, *B. Elliot 16363* (COLO-L-0050874), 40.17524 -106.42466, 2310 m, 31.viii.2014, *B. Elliot 16372* (COLO-L-0050869), 40.17051 -106.42274, 2316 m, 31.viii.2014, *B. Elliot 16373* (COLO-L-0050872).

*Xanthoparmelia lavicola* (Gyel.) Hale, Mycotaxon 33: 404. 1988.  $\equiv$  *Parmelia lavicola* Gyel., Repert. Spec. Nov. Regni Veg. 36: 157. 1934. **TYPE: MEXICO:** La Estrella, 9.ix.1928, *Frère Amable 600* (BP [image!], lectotype designated by Hale 1990: 74).

**FIGURE 8.**

**DESCRIPTION.** – **Thallus** suborbicular; tightly to moderately adnate; saxicolous. **Lobes** subirregular; somewhat divided, 1–3 mm wide; subimbricate, flat to subconvolute; margins usually black, apices crenate. **Upper surface** yellow-green; epruinose, smooth, shiny, moderately to densely isidiate. **Lower surface** pale; rhizines dark brown, occurring frequently. **Apothecia** not seen. **Pycnidia** not seen. **Isidia** at first globose, then becoming cylindrical and branching moderately; at times black or brown on tips.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: psoromic acid (major), unknown compound (trace), 2'-*O*- demethylpsoromic acid (trace), norstictic acid (trace). Spot tests: cortex: K-, C-, KC-, P- medulla: K+ yellow, C-, KC-, P+ yellow to orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia lavicola* occurs primarily in southwestern Arizona and northeastern Mexico (Nash and Elix 2004). Colorado specimens have been collected from both the eastern and western slopes in prairie and rocky areas at low elevations ranging from 1433–1676 m (4700–5500 ft; Figure 2). It should be noted that of the five collections housed at COLO, three were vouchered from White Rocks Open Space in the City of Boulder, which is a unique outcropping of Fox Hills sandstone (Tripp 2015).

NOTES. – *Xanthoparmelia lavicola* resembles *X. mexicana* (Figure 10) as well as *X. plittii* (Figure 15) morphologically, however *X. lavicola* has a thallus that is more consistently tightly adnate. Regardless of thallus adnation, *X. lavicola* can readily be characterized by the presence of psoromic acid as a major metabolite, which is otherwise rare in western North American *Xanthoparmelia* as a whole (Nash & Elix 2004; see Table 2 herein).

TLC conducted by M.E. Hale on the lectotype housed at BP (as annotated on the packet in 1987) indicated the presence of psoromic and norpsoromic acids; TLC conducted at a later date by an unknown researcher indicated the presence of fumarprotocetraric and usnic acids. We here err on the side of M. Hale’s circumscription as a taxonomic expert in this group, acknowledging more work including additional TLC is needed on type material. We therefore circumscribe *X. lavicola* as a species that contains psoromic acid, not fumarprotocetraric acid, in agreement with Hale’s original documentation (Barcenas-Peña 2021; Egan et al. 2002; Hale 1990).

*Additional specimens examined.* – **U.S.A. COLORADO. BOULDER CO.:** City of Boulder Open Space, Hedgecock Property, just S of S. Boulder Creek W. Trail; approx. 460 ft E of intersection w/ Mesa Trail, 39.94552° -105.261629°, 5736 ft, 12.x.2015, V. Diaz 82 (COLO-L-0055794). **JEFFERSON CO.:** 7 mi S of Boulder, on Rocky Flats Pediment, 26.vi.1973, G. Kunkel C-42 (COLO-L-0047859); White Rocks Open Space, 5146 ft., 4.x.2014, E.A. Tripp 4839 (COLO-L-0050573), E.A. Tripp 4874 (COLO-L-0050604). **LAS ANIMAS CO.:** W bank of Trinchera Creek, 25 mi E of Trinidad, 1676 m, 4.vii.1957, S. Shushan s.n. (COLO-L-0047831). **WASHINGTON CO.:** 6 mi WNW of Akron, 1433 m, 6.vi.1954, S. Shushan s.n. (COLO-L-0047848).

*Xanthoparmelia lineola* (Berry) Hale, Phytologia 28: 486. 1974.  $\equiv$  *Parmelia lineola* E.C. Berry, Ann. Missouri Bot. Gard. 28: 77. 1941. **TYPE: U.S.A. ARIZONA. APACHE CO.:** “Open woods, 3 miles northwest of Ft. Defiance” (*fide* protologue), 12.vi.1938, L. Hubricht B1170; NY [02607268] [image!], isotype **designated here** (Mycobank #10006076).

**FIGURE 9.**

**DESCRIPTION.** – **Thallus** usually orbicular; tightly adnate to substrate; saxicolous. **Lobes** irregular; at times dichotomously branched and divided, 1–3 mm wide; separate (usually at margins) to imbricate; margins blackening. **Upper surface** yellow-green, smooth and shiny, intensely cracking and darkening towards older portions of thallus. **Lower surface** dark brown; rhizines dark brown, occurring frequently. **Apothecia** common, sessile, disks light to dark brown; margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless; 7–8 x 4–5  $\mu$ m. **Pycnidia** frequent to occasional, black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red, C-, KC-, P+ orange, UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia lineola* has been collected extensively in the southwestern United States and tends to grow at moderate to high elevations between 914–3658 meters (3000–12000 ft) on sun-exposed rocks in arid environments (Berry 1941; Nash 1974 Nash and Elix 2004; CNALH 2016). In Colorado, this species is found throughout the southern Rockies in mountainous regions from elevations ranging between 1829–3048 m (6000–10000 ft; Figure 2).

**NOTES.** – *Xanthoparmelia lineola* is a member of the salazinic acid containing group that includes *X. chlorochroa* (Figure 3), *X. coloradoensis* (Figure 4), *X. idahoensis* (Figure 7), *X. lineola* (Figure 9), *X. mexicana* (Figure 10), *X. stenophylla* (Figure 17), and *X. wyomingica* (Figure 20). It can be distinguished from these other species by being the most tightly adnate member of this group.





**Figure 9.** *Xanthoparmelia lineola* is one of the most common salazinic acid-containing species in Colorado. Note its very tight adnation to the rock, which what separates it from *X. coloradoensis* and *X. wyomingica*.

Hale (1990) cited the holotype (collection B11700) being located at US. However, the specimen he appeared to examine at the US herbarium is labeled collection B1181. Berry clearly cited B1170 as the type specimen in the protologue cited above. While it is possible to speculate Berry mistakenly switched the labels between the two specimens with the intent of designating the US specimen as the type, the authors will adhere to what is stated in the protologue and assign collection B1170 located at NY the type specimen.

*Additional specimens examined.* – **U.S.A. COLORADO.** ALAMOSA CO.: Great Sand Dunes National Monument, trail to Mosca Pass, 10.vi.1954, *S. Shushan s.n.* (COLO-L-0047581). BOULDER CO.: Boulder Canyon ca. 0.5 mi up from mouth, 1800 m, 7.vii.1976, *W.A. Weber s.n.*, (COLO-L-0048005); Boulder Canyon near Tungsten, 8000 ft, 29.iv.1959, *S. Shushan s.n.* (COLO-L-0048023); Steamboat Mountain, 2 mi. NW of Lyons, 1829 m, 15.x.1972, *W.A. Weber s.n.* (COLO-L-0047740); summit of Niwot Ridge, 3505 m, 19.vii.1951, *M.E Hale s.n.* (COLO-L-0047805); Roosevelt National Forest, between backyard of 6251 Lefthand Canyon and Cocktail Rock, 0.3 mi W of Lee Hill Rd. and 0.2 mi S of Lefthand Canyon Dr., 2195 m, 28.iii.2014, *E.A. Tripp 4893* (COLO-L-0050912), *E.A. Tripp 4894* (COLO-L-0050913); City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.144196° -105.265447°, 5568 ft, 19.vi.2015, *V. Diaz 1* (COLO-L-0055817), 40.143867° -105.265403°, 5568 ft, 19.vi.2015, *V. Diaz 5* (COLO-L-0055879), 40.144591° -105.26385°, 5550 ft, 19.vi.2015, *V. Diaz 6* (COLO-L-0055819), 40.144961° -105.265085°, 5568 ft, 26.vi.2015, *V. Diaz 16* (COLO-L-0055814); City of Boulder Open Space, Schneider Property, approx. 3.5 mi W of N Foothills Parkway/US 3, 40.079317° -105.292306°, 5328 ft, 26.vi.2015, *V. Diaz 8* (COLO-L-0055820); City of Boulder Open Space, Schneider Property, approx. 0.5 mi W of N Foothills Parkway/US 36, 40.079628° -105.289906°, 5328 ft, 26.vi.2015, *V. Diaz 22* (COLO-L-0055888), 40.079394° -105.289748°, 5328 ft, 26.vi.2015, *V. Diaz 23* (COLO-L-0055843); City of Boulder Open Space, Schneider Property, approx. 1.5 mi W of N Foothills Parkway/US 36, 40.079514° -105.295446°, 5328 ft, 26.vi.2015, *V. Diaz 25* (COLO-L-

0055890); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 75 ft S of McClintock Upper Trail, 39.990115° -105.285999°, 6117 ft, 29.vi.2015, *V. Diaz* 33 (COLO-L-0055837); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.4 mi from trailhead, 40.025633° -105.300146°, 5931 ft, 10.vii.2015, *V. Diaz* 55 (COLO-L-0055834); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.45 mi from trailhead, 40.025893° -105.30021°, 5931 ft, 10.vii.2015, *V. Diaz* 56 (COLO-L-0055823); City of Boulder Open Space, Van Vleet Property, just W of S. Cherryvale Rd. and just S of Marshallville Ditch, 39.974252° -105.213577°, 5463 ft, 17.vii.2015, *V. Diaz* 65 (COLO-L-0055892); City of Boulder Open Space, Yunker Property, approx. 1500 ft N of Marshall Rd. and approx. 1.5 mi W of intersection w/ the Denver Turnpike, 39.965496, -105.195661°, 5693 ft, 17.vii.2015, *V. Diaz* 68 (COLO-L-0055884); City of Boulder Open Space, Abbey Property, just off of N Fork Shanahan Trail approx. 380 ft N of intersection w/ Leigh Connector-S, 39.965576° -105.260345°, 5755 ft, 24.viii.2015, *V. Diaz* 73 (COLO-L-0055799); City of Boulder Open Space, Flatirons Vista Property, approx. 100 ft S of Prairie Vista Trail, 39.921914° -105.243967°, 6054 ft, 27.viii.2015, *V. Diaz* 78 (COLO-L-0055802); City of Boulder Open Space, Matterhorn Property, approx. 400 ft W of Foothills Parkway and 0.5 mi S of Davidson Ditch, 39.946363° -105.238597°, 5629 ft, 27.viii.2015, *V. Diaz* 79 (COLO-L-0055885); City of Boulder Open Space, Hedgecock Property, just S of S. Boulder Creek W. Trail; approx. 460 ft E of intersection w/ Mesa Trail, 39.94552° -105.261629°, 5736 ft, 12.x.2015, *V. Diaz* 80 (COLO-L-0055803). CUSTER CO.: San Isabel National Forest, 2 mi N of Ophir Campground, 2560 m, 13.vi.1951, *S. Shushan s.n.* (COLO-L-0047799). JACKSON CO.: along E edge of Big Creek Lake, E slope of Park Range, 24 mi W of Cowdrey, 2804 m, 29.v.1955, *S. Shushan s.n.* (COLO-L-0047781). LA PLATA CO.: 10-12 mi N of Hesperus, 2743 m, 9.vi.1958, *S. Shushan s.n.* (COLO-L-0047775). LAS ANIMAS CO.: 0.4 mi N of Morley, 2256 m, 10.vi.1951, *S. Shushan s.n.* (COLO-L-0047787); Comanche National Grassland, vicinity of Picketwire Canyon and Withers Campground, above (W of) Purgatory River, Saxicolous, 37.658953 -103.571774, 5.vi.2015, *E.A. Tripp* 5638 (COLO-L-0051297), *E.A. Tripp* 5640 (COLO-L-0051299); Chancellor Ranch, unnamed N-facing Canyon that drains into the Purgatory River, E of Route 143 just S of its crossing of the Purgatory, 37.345259 -103.893802, 7.vi.2015, *E.A. Tripp* 5673 (COLO-L-0051335). MONTROSE CO.: above West Paradox Creek, W end of Paradox Valley, below Buckeye Reservoir, 38.42000 -109.03600, 1768 m, 30.v.1960m, *W.A. Weber s.n.* (COLO-L-0047751). SAN JUAN CO.: South Mineral Creek Campground, 2926 m, 26.vi.1954, *J. Douglass s.n.* (COLO-L-0047739).

*Xanthoparmelia mexicana* (Gyel.) Hale, Phytologia 28: 486. 1974.  $\equiv$  *Parmelia mexicana* Gyel., Repert. Spec. Nov. Regni Veg. 31: 281. 1931. **TYPE: MEXICO:** San Jeronimo, 7.x.1926, *Frère Amable* 676 (BP [image!], lectotype designated by Hale 1990: 74: 147).

#### FIGURE 10.

**DESCRIPTION.** – **Thallus** moderately to tightly adnate to substrate; saxicolous. **Lobes** irregular; somewhat divided, 3–10 mm wide; separate to imbricate; margins usually dark brown entire to crenate. **Upper surface** yellow-green; epruinose, smooth, cracking and becoming rugose towards older portions of thallus. **Lower surface** pale brown; rhizines dark brown. **Apothecia** not seen. **Isidia** at first globose, then becoming cylindrical and branching frequently; at times black or brown on tips. **Pycnidia** infrequent to occasional, black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow to red, C-, KC-, P+ orange-red; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia mexicana* is almost exclusively found in western North America, particularly in the southwestern region of the United States (Hale 1990, Nash and Elix 2004). In Colorado, it can be found in the southern Rockies, most commonly on the eastern slope in canyons or on ridges at elevations from 1524–2743 m (5000–9000 ft; Figure 2).

**NOTES.** – *Xanthoparmelia mexicana* is considered the isidiate counterpart of *X. lineola* (Figure 9) and is the most common salazinic-containing asexual species found in the state.



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med. Pd + orange!  
K + yellow → red,  
th. pale below.

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**Figure 10.** *Xanthoparmelia mexicana* is one of the most common asexual *Xanthoparmelia* in Colorado. Note the resemblance in moderate to tight adnation, lobe size and shape, and color to other asexual species.

*Additional specimens examined.* – U.S.A. COLORADO. BOULDER CO.: S base of Steamboat Mountain, 1.5 mi N of Lyons, 1676 m, 10.iii.1959, S. Shushan s.n. (COLO-L-0047818); Upper Gregory Canyon, ca. 1 mi W of Boulder and 1 mi N of Green Mountain Summit, 1940–1980 m, 17.v.1975, G. Kunkel s.n. (COLO-L-0047824); Lytle Formation, Dakota Ridge, Rabbit Mountain, 4 mi NE of Lyons just above the Little Thompson River, 1585–1631m, 15.viii.1960, R.A. Anderson s.n. (COLO-L-0047830); Wild Basin, 1.5 mi up Finch Lake Trail, 2743 m, 29.vi.1962, R.A. Anderson 2206 (COLO-L-0047836); Boulder Canyon, ca. 0.5 mi up from mouth, 1800 m, 7.vii.1976, W.A. Weber s.n. (COLO-L-0047842); City of Boulder Open Space, Circle of Friends Property, along Sunshine Canyon Trail on S side of Sunshine Canyon Drive, 40.023385° -105.302384°, 5633 ft, 26.vi.2015, V. Diaz 15 (COLO-L-0055813); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.5 mi from trailhead, 40.027523° -105.302771°, 5557 ft, 10.vii.2015, V. Diaz 43 (COLO-L-0055840); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.4 mi from trailhead, 40.0254° -105.299847°, 5931 ft, 10.vii.2015, V. Diaz 47 (COLO-L-0055579), V. Diaz 49 (COLO-L-0055830); City of Boulder Open Space, Circle of Friends Property, on W-facing slopes just W off of Mount Sanitas Trail, 40.026754° -105.30149°, 5931 ft, 10.vii.2015, V. Diaz 51 (COLO-L-0055795); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx 0.2 mi from trailhead, 40.021883° -105.29828°, 5931 ft, 10.vii.2015, V. Diaz 53 (COLO-L-0055832), V. Diaz 54 (COLO-L-0055833); City of Boulder Open Space, Jewel Mountain Property, approx. 50 ft E of Plainview Rd. and approx. 400 ft S of Coal Creek, 39.877702° -105.268981°, 6464 ft, 24.vii.2015, V. Diaz 70 (COLO-L-0055808); City of Boulder Open Space, Fraiser Farms Property, at the intersection of Mesa and Upper Big Bluestem Trails, 39.953578° -105.279707°, 6092 ft, 14.viii.2015, V. Diaz 75 (COLO-L-0055875). EL PASO CO.: Bear Creek Canyon, W of Colorado Springs, 12.vi.1918, C.C. Plitt s.n. (COLO-L-0047812). GARFIELD CO.: 5 mi N of Rifle, W side of Rifle Creek along S edge of Grand Hogback, 2 mi SW of Rifle Gap, 1800 m, 12.vi.1974, W.A. Weber s.n. (COLO-L-0047871); 9.8 mi W of Grand Valley, 4.ix.1957, S. Shushan s.n. (COLO-L-0047877). JACKSON CO.: Big Creek Lake, ca. 24 mi NW of Cowdrey, E slope of Park Range, 2804 m, 29.v.1955, S. Shushan s.n. (COLO-L-0047829). LARIMER CO.: Rocky Mountain National Park, ESE of Endovalley Campground, on extensive N-facing talus, 2658–2707 m, 17.vi.1966, R.A. Anderson 5407 (COLO-L-0047811); Owl Canyon, 9.7 mi N

of Teds Place (junction of Highways 287 and 14), 1829 m, 6.iv.1955, *S. Shushan s.n.* (COLO-L-0047817); Rocky Mountain National Park, SW slope of Deer Mountain, 2667–2804 m, 25.viii.1962, *R.A. Anderson 3567* (COLO-L-0047823); Mummy Range, Mt. Chiquita, 3414–3627 m, 14.vii.1963, *R.A. Anderson 4019* (COLO-L-0047835); 4.5 mi SW of Ft. Collins, just above Horsetooth Reservoir, Sec. 32, & T. 6 N Sec. 5, 1661–1798 m, 1.vii.1960, *R.A. Anderson s.n.* (COLO-L-0047837); near Horseshoe Park and road to Endovalley Campground, 2652–2804 m, 23.vii.1962, *R.A. Anderson 2801* (COLO-L-0047841); South Lateral Moraine, 2469–2591 m, 17.vii.1962, *R.A. Anderson 2642* (COLO-L-0047847); Estes Park, 9 mi SE of, or 14 mi NW of Lyons, off Denver highway, 2286 m, 26.vii.1949, *W. Kiener 24765* (COLO-L-0047853). MESA CO.: ca. 7 mi SW of Whitewater on benches above East Creek north of Gibbler Gulch, 1.vi.1973, *W.A. Weber s.n.* (COLO-L-0047813), *W.A. Weber s.n.* (COLO-L-0047878). N end of Colorado National Monument, ca. 3 mi S of Fruita, Dakota-Morrison formation, base of escarpment, 1372 m, 12.v.1955, *S. Shushan s.n.* (COLO-L-0047819), *S. Shushan s.n.* (COLO-L-0047825). MONTEZUMA CO.: Beaver Creek, 6 mi N of McPhee, 2286 m, 12.vi.1958, *S. Shushan s.n.* (COLO-L-0047872). MONTROSE CO.: Escarpment above West Paradox Creek, W end of Paradox Valley, below Buckeye Reservoir, 38.42000 -109.03600, 1768 m, 30.v.1960, *W.A. Weber s.n.* (COLO-L-0047866). PARK CO.: 11.3 mi E of Jefferson on road to Lost Creek Park, 3048 m, 3.vii.1955, *S. Shushan s.n.* (COLO-L-0047860). SUMMIT CO.: E of Lake Dillon near Keysone, 39.60000 -106.00000, 2700 m, 11.ix.1981, *W.A. Weber s.n.* (COLO-L-0047854).

*Xanthoparmelia monticola* (J.P.Dey) Hale, Mycotaxon 33: 404. 1988.  $\equiv$  *Parmelia monticola* J.P.Dey, Castanea 39: 360. 1974. **TYPE: U.S.A.** NORTH CAROLINA. BUNCOMBE CO.: Craggy Dome in the Great Craggy Mountains. On rock of outcrop in heath bald, 1972, *J.P. Dey 1509* (DUKE [0000170] [image!], holotype; NY [1231673] n.v., isotype).

#### FIGURE 11.

**DESCRIPTION.** – **Thallus** loosely adnate; saxicolous. **Lobes** sublinear; 1–2.5 mm wide; contiguous to imbricate; margins blackening, entire to crenate. **Upper surface** yellow-green; epruinose, smooth. **Lower surface** light to dark brown; rhizines light to dark brown, occurring frequently. **Apothecia** common, substipitate, light to dark brown, margins smooth. **Ascospores** absent in Colorado material. **Pycnidia** frequent to occasional, black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: fumarprotocetraric acid (major), physodalic acid (trace), protocetraric acid (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K-, C-, KC-, P+ orange to red; UV-.

**ECOLOGY AND DISTRIBUTION.** – To our knowledge, there are only four records of *Xanthoparmelia monticola* in Colorado, three from Boulder County and one from Larimer county at elevations between approximately 1829–2700 m (6000–8900 ft; Figure 2). We have seen and studied the three located at COLO (cited below), which were made on the eastern slope. It is possible that additional material may exist, albeit under different names in other herbaria, however this seems relatively unlikely given the amount of material studied by earlier experts including M. Hale and T. Nash. It may therefore be an uncommon to rare species in Colorado, considering the limited number of voucher specimens that exist- COLO (3) and ASU (1). *Xanthoparmelia monticola* is globally ranked by the Nature Conservancy as a G2 species, a rank given to species with only 6–20 populations known worldwide (Perlmutter 2009).

**NOTES.** – The presence of physodalic acid is very rare in *Xanthoparmelia* (Hale 1990). This in addition to the production of fumarprotocetraric and trace protocetraric acid makes this species very chemically distinctive. It might be most commonly confused with *X. novomexicana* (Figure 14), which also contains fumarprotocetraric acid. However, *X. novomexicana* lacks physodalic acid and is also much more tightly adnate.

While Dey did not describe protocetraric acid in the protologue, there was mention of traces of an unknown substance that he stated may possibly represent sublimbatic acid. Because protocetraric and sublimbatic acid have very similar  $R_F$  values (Elix 2014), it is possible that the unknown trace described by Dey was actually protocetraric acid. In addition, Dey also stated there were traces of stictic acid in the holotype. It was later concluded (by J. Johnston in 1983, as annotated on the specimen) that the stictic acid traces were due to a contaminant fragment of *Xanthoparmelia conspersa*.



L-63356



CRYPTOGAMIC HERBARIUM  
UNIVERSITY OF COLORADO

**Figure 11.** *Xanthoparmelia monticola* is differentiated from the chemically identical *X. novomexicana* by its looser adnation level. Note the lobes lifting off of the substrate.

*Additional specimens examined.* – **U.S.A. COLORADO.** BOULDER CO.: Shanahan Mesa, a colluvial fan spreading out from the base of Bear Peak, S edge of Boulder, 1900 m, 2.v.1998, W.A. Weber *s.n.* (COLO-L-0047843); City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.144196° -105.265447°, 5568 ft., 19.vi.2015, V. Diaz 3 (COLO-L-0055818); City of Boulder Open Space, Austin-Russell Property, along Blue Ski Jump and Bell/ Baird Trails, approx. 0.5 mi S of Baseline Rd., 39.996228°, -105.289193°, 6095 ft., 26.vi.2015, V. Diaz 11 (COLO-L-0055811). LARIMER CO.: Estes Park, 9 miles SE of, or 14 mi NW of Lyons, off Denver Highway, 2286 m, 26.vii.1976, W. Kiener L45981 (COLO-L-0048049).

*Xanthoparmelia mougeotii* (Schaer. in D. Dietr.) Hale, Phytologia 28: 488. 1974.  $\equiv$  *Parmelia mougeotii* Schaer. in D. Dietr., Deutschl. Kryptog. Gewächse 4 Abth.: 118. 1846. **TYPE:** Tab 288, f 288 (lower half of plate) [image!], lectotype designated by Elix & Thell 2011: 141). **REPLACEMENT TYPE:** **FRANCE:** Vosges, Bruyères, “Ad saxa silacea in summo m. Heledré prope Brujerium Mougeot.” [fide specimen], Schaerer, Lich. Helv. Exs. No. 548 (UPS [image!], epitype designated by Elix & Thell (2011: 141); FH [image!], isoepitype).

**FIGURE 12.**

**DESCRIPTION.** – **Thallus** tightly adnate; saxicolous. **Lobes** irregular; deeply divided, 3–10 mm wide; separate to imbricate; margins darkening, entire to crenate at apices. **Upper Surface** dark yellow-green and sometimes partially brown in older sections; shiny, cracking in older portions of thallus. **Lower Surface** dark brown, shiny; rhizines dark brown. **Soredia** frequent; in orbicular clumps; light yellow-green. **Apothecia** not seen. **Pycnidia** infrequent, sunken below upper cortex, black.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: stictic acid (major), constictic acid (trace), norstictic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla K+ yellow, C-, KC-, P+ orange; UV-.





**Figure 12.** *Xanthoparmelia mougeotii* is distinctive from other asexual species in that it is the only sorediate *Xanthoparmelia* known from Colorado.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia mougeotii* is the only currently identified sorediate species of this genus in Colorado, and very rare with only eight confirmed records within the state, all collected in one general area of Rocky Mountain National Park at 2682–2774 m (8800–9100 ft) in Spruce Canyon in the same year (Figure 2). While it initially appears that *X. mougeotii* is restricted to subalpine habitats, the ecology and full distribution of *X. mougeotii* is difficult to decipher until more Colorado collections of this species are made. In other regions of the United States, it has been collected almost exclusively on the Pacific Coast at lower elevations (Hale 1990; Leavitt 2010).

**NOTES.** – The above description is based on the only two specimens representing this species that are housed at COLO in addition to study of the protologue and the original material cited above. The secondary metabolites cited above were taken from Nash and Elix 2004 because the COLO collections are extremely sparse and too scant for destructive sampling.

Elix and Thell (2011) typified the name when they designated the illustration cited above as lectotype and the Schaerer exsiccate at UPS as a neotype (an error to be corrected to epitype). Note that Hale (1974, 1990) incorrectly cited Schaerer (1850) as the protologue, rather than the earlier edition of the work in 1846. Additionally, Elix and Thell (2011) incorrectly cited the starting page number of the protologue as 24 instead of 118, which has been corrected above.

*Additional specimens examined.* – **U.S.A. COLORADO.** LARIMER CO.: Rocky Mountain National Park, Spruce Canyon, along Spruce Creek, ca. 1 mi from mouth of Forest Canyon, 40.34967°N, 105.67576°W, 2682–2774 m, 14.vi.1966, R.A. Anderson 5302 (COLO-L-0047890, COLO-L-0047896).





**Figure 13.** *Xanthoparmelia neochlorochroa* resembles other vagrant taxa in that it has dichotomous branching and forms rosettes.

*Xanthoparmelia neochlorochroa* Hale, Mycotaxon 30: 324. 1987. **TYPE:** U.S.A. IDAHO. LEMHI CO.: 18.vi.1973, *D.E. Anderegg 1480* (US [00051120] [image!], holotype).

**FIGURE 13.**

**DESCRIPTION.** – **Thallus** vagrant. **Lobes** sublinear; dichotomously branched and deeply divided, 3–15 mm wide; separate to subimbricate; margins sometimes blackening at tips. **Upper surface** yellow-green; smooth, cracking and darkening towards older portions of thallus. **Lower surface** pale to dark brown and shiny; rhizines brown, occurring frequently. **Apothecia** not seen. **Pycnidia** infrequent, sunken below upper cortex, black.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: connorstictic acid (trace), norstictic acid (major). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow to red, C-, KC-, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia neochlorochroa* occurs in northern Colorado on north-facing mountain slopes between elevations of 1829–2438 m (6000–8000 ft; Figure 2). Prior authors have shown that vagrant lichens thrive in areas with low vascular plant biomass, low-nutrient soil, elevated frequencies of drought, and higher exposure to wind (MacCracken et al. 1983, Rosentreter 1993). Vagrant lichens are also common in grazing lands, which has led to poisoning of livestock (Dailey et al. 2008).

**NOTES.** – This species resembles *Xanthoparmelia chlorochroa* (Figure 3) morphologically but differs chemically owing to its lack of salazinic acid. Note that the  $R_F$  value of salazinic acid is 4, while the  $R_F$  value of connorstictic acid is 3 (Elix 2014). This can pose difficulties in separating *Xanthoparmelia chlorochroa* and *X. neochlorochroa*, as the latter manufactures connorstictic acid in trace amounts.





**Figure 14.** *Xanthoparmelia novomexicana* is characteristically very tightly adnate, similar to *X. lineola*. This is also useful in differentiating between *X. monticola* which is chemically identical.

*Additional specimens examined.* – **U.S.A. COLORADO.** GRAND CO.: approx. 2.2 air mi NE of Kremmling. S of Wolford Mountain in the vicinity of Cow Gulch, near wooden power line, 40.10158 - 106.38417, 2387 m, 30.viii.2014, *B. Elliot* 16350 (COLO-L-0050855). MOFFAT CO.: 13 mi NE of Craig, 40.66667 -107.46667, 1965 m, 26.viii.1975, *S. Shushan* 8909 (COLO-L-0047950). SUMMIT CO.: approx. 10.5 air mi S of Kremmling and 2 mi N of Green Mountain Reservoir, E of Hwy 9 near junction of Hwy 9 and Rd. 381, 39.91787 -106.32752, 2362 m, 30.viii.2014, *B. Elliot* 16358 (COLO-L-0050875).

*Xanthoparmelia novomexicana* (Gyel.) Hale, *Phytologia* 28: 488. 1974.  $\equiv$  *Parmelia novo-mexicana* Gyel., *Repert. Spec. Nov. Regni Veg.* 36: 161. 1934. **TYPE:** U.S.A. NEW MEXICO. Las Vegas, 18.ii.1930, *Frère Arsène Brouard* 20647 (BP [image!], lectotype designated by Hale 1990: 166).

= *Xanthoparmelia arseneana* (Gyel.) Hale, *Phytologia* 28: 486. 1974.  $\equiv$  *Parmelia arseneana* Gyel., *Ann. Mycol.* 36: 269. 1938. **TYPE:** U.S.A. NEW MEXICO: Las Vegas, Gallinas Cañon N., ca. 2300 m.s.m. alt., 1930, *Frère Arsène* 21191 (BP [image!], lectotype designated by Hale 1990: 166).

#### FIGURE 14.

**DESCRIPTION.** – **Thallus** tightly to moderately adnate; saxicolous. **Lobes** sublinear; 5–20 mm wide; strongly imbricate towards center of thallus, and non-imbricate at margins; plane to slightly convex margins browning a tips; apices entire to moderately crenulate. **Upper surface** yellow-green; epruinose, smooth and occasionally rugose, areolate, and blackening towards the center. **Lower surface** pale and darkening towards tips; rhizines dark brown to black, occurring frequently. **Apothecia** moderately present, sessile, disks brown, margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless; 8–9  $\times$  4–5  $\mu$ m. **Pycnidia** frequent, sunken below upper cortex, black.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: fumarprotocetraric acid (major), protocetraric acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K-, C-, KC-, P+ orange to red; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia novomexicana* is found in montane western regions in North America from Washington and Montana, U.S.A., south into Oaxaca, Mexico (CNALH 2016, Hale 1990, Nash and Elix 2004). The ecology of this species is relatively restricted compared to other *Xanthoparmelia* species, as it is typically only found at elevations ranging from 2073–3353 m (6800–11000 ft) (Nash 1974).

NOTES. – *Xanthoparmelia novomexicana* is morphologically similar to *X. lineola* (Figure 9) but differs chemically in that it contains fumarprotocetraric acid instead of salazinic acid (Table 2) thus yielding a K- medulla (vs. K+ red in *X. lineola*). In addition, *X. novomexicana* has a much more limited range compared to *X. lineola* (Nash 1974).

TLC conducted on the lectotype at BP (researcher unknown; packet annotated in 1987) indicated the presence of succinprotocetraric acid. J.A. Elix also conducted TLC on the same specimen (annotated on the packet on 23 March 2004), and he noted the presence of confumarprotocetraric (trace) and virensic (minor) acids.

The decision to here propose *Xanthoparmelia arseneana* as a synonym of *X. novomexicana* is based on the examination of protologue descriptions, type specimens (the holotype designated in the protologue was presumably destroyed in Bouly de Lesdain's Herbarium in Dunkerque, France during WWII), as well as Hale's determination of this synonymy in his 1990 publication. In the protologue of *X. novomexicana*, Gyelnik stated the underside of the thallus was "blackening". Based on this phrasing, we interpret this as the underside is otherwise pale, with blackening towards the inner portions. In addition, Gyelnik had a tendency of describing species that, within modern species delimitations, have been determined to be one in the same. (Hale 1990).

*Additional specimens examined.* – U.S.A. COLORADO. BOULDER CO.: Boulder Canyon ca. 0.5 mi up from mouth, 1800 m, 7.vii.1976, W.A. Weber *s.n.* (COLO-L-0048127); First Flatiron, just above mouth of Gregory Canyon, 1800 m, 6.vii.1976, W.A. Weber *s.n.* (COLO-L-0047891). HUERFANO CO.: Apishapa Pass, S of La Veta, 10.vi.1960, S. Shushan *s.n.* (COLO-L-0047499).

*Xanthoparmelia plittii* (Gyel.) Hale, Phytologia 28: 488. 1974.  $\equiv$  *Parmelia plittii* Gyel. Repert. Spec. Nov. Regni Veg. 31: 287. 1931. **TYPE:** U.S.A. MARYLAND. BALTIMORE CO.: Liberty Road at Gwynna Falls, 31.iii.1908, C.C. Plitt *s.n.* (BP [image!], lectotype designated by Hale 1990: 175).

#### FIGURE 15.

DESCRIPTION. – **Thallus** moderately to tightly adnate; saxicolous. **Lobes** irregular; moderately to deeply divided, 0.1–3.5 mm wide; non-imbricate to moderately imbricate; margins usually black. **Upper surface** yellow-green; shiny and epruinose; smooth, cracking and blackening with age. **Lower surface** pale, shiny; rhizines dark brown. **Apothecia** not seen. **Isidia** frequent to dense, cylindrical, then branching and darkening with age. **Pycnidia** moderate, black sunken below upper cortex.

CHEMISTRY. – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor), constictic acid (trace), cryptostictic acid (trace), unknown compound (trace). Spot tests: cortex: K-, C-, KC, P-; medulla: K+ yellow to orange, C-, KC+ red, P+ yellow then dark orange; UV-.

ECOLOGY AND DISTRIBUTION. – *Xanthoparmelia plittii* is found very prevalently across both North and South America, including commonly in eastern North America (Brodo et al. 2001, Hale 1990, Nash and Elix 2004). In Colorado, it is abundant in the southern Rocky Mountains, on both the eastern and western slopes between 1768–2865 m (5800–9400 ft; Figure 2).

NOTES. – *Xanthoparmelia plittii* is considered the isidiate counterpart of the fertile *X. cumberlandia* (Figure 6). Both share ecological, chemical, and morphological features but differ in reproductive mode. *Xanthoparmelia plittii* also resembles *X. conspersa* (Figure 5), however the latter species has a black lower surface and is occasionally fertile (both in Colorado material and found on type specimen; C.C. Plitt, *s.n.*).



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**Figure 15.** *Xanthoparmelia plittii* is the most common stictic acid-containing asexual species of *Xanthoparmelia* in Colorado. Similarity to *X. mexicana* means TLC is necessary to differentiate the two.

*Additional specimens examined.* – **U.S.A. COLORADO. BOULDER CO.:** City of Boulder Open Space, Johnson Property, NE corner of property, just S of intersection of Nelson Rd. and 39th St., 40.144196° -105.265447°, 5568 ft, 19.vi.2015, V. Diaz 4 (COLO-L-0055880); City of Boulder Open Space, Circle of Friends Property, along Sunshine Canyon Trail on S side of Sunshine Canyon Drive, 40.022072° -105.300673°, 5587 ft, 26.vi.2015, V. Diaz 20 (COLO-L-0055877); City of Boulder Open Space, Schneider Property, approx. 0.5 mi W of N Foothills Parkway/US36, in dry, 40.079628° -105.289906°, 5328 ft, 26.vi.2015, V. Diaz 24 (COLO-L-0055844); City of Boulder Open Space, Hogan Brothers Property, approx. 200 ft. E of S Cherryvale Rd., 39.962798° -105.211992°, 5546 ft., 17.vii.2015, V. Diaz 62 (COLO-L-0055828); City of Boulder Open Space, Van Vleet Property, approx. 20 ft. W of S Cherryvale Rd. in Marshall Ditch, on banks of Marshall Ditch in sun-exposed area, 39.974564° -105.213802°, 5463 ft, 17.vii.2015, V. Diaz 67 (COLO-L-0055806); City of Boulder Open Space, Abbey Property, just off of N Fork Shanahan Trail approx. 380 ft. N of the intersection w/ Leigh Connector-S, 39.965576° -105.260345°, 5755 ft, 14.viii.2015, V. Diaz 72 (COLO-L-0055809). **GUNNISON CO.:** Lytle Formation, Dakota Group, T1N R71W SEC1, 5800–6400 ft, 1.viii.1959, R.A. Anderson s.n. (COLO-L-0047617); Blue Mesa Cutoff road at Hole-in-the-wall, 2438 m, 27.vii.1955, W.A. Weber s.n. (COLO-L-0047928). **HINSDALE CO.:** Cebolla Creek Campground, between Cathedral and Slumgullion Pass, 2865 m, 29.vii.1964, W.A. Weber s.n. (COLO-L-0047865). **LA PLATA CO.:** 3 mi N of Bondad, just E of Animas River, 1829 m, 12.vi.1955, S. Shushan s.n. (COLO-L-0047922). **LARIMER CO.:** Dakota Ridge, 22 mi N of Ft. Collins, 2 mi SE of Table Mt., 1920–1981 m, 23.x.1959, R.A. Anderson s.n. (COLO-L-0047916). **MOFFAT CO.:** at the northern end of Dinosaur National Monument, the entrance of the Green River into the Canyon of Lodore, about 1 mi S of Browns Park, above camp, 29.vii.1962, S. Flowers s.n. (COLO-L-0047910). **MONTEZUMA CO.:** ca. 30 mi W of Cortez, vicinity of junction of Yellowjacket and McElmo Creek, 1463 m, 10.vi.1958, S. Shushan s.n. (COLO-L-0047904).





**Figure 16.** *Xanthoparmelia psoromifera* is morphologically similar to its asexual counterpart *X. lavicola*. Due to the tight adnation and lobe type, it often resembles *X. lineola* and *X. novomexicana*.

*Xanthoparmelia psoromifera* (Kurok. ex Hale) Hale, Phytologia 28: 488. 1974.  $\equiv$  *Parmelia psoromifera* Kurok. ex Hale The Bryologist 70: 418. 1967. **TYPE: MEXICO.** JALISCO: 25 km S of Guadalajara, vii.1961, M. Wirth 22 (US [00068977] [image!], holotype!).

**FIGURE 16.**

**DESCRIPTION.** – **Thallus** moderately to tightly adnate; saxicolous. **Lobes** sublinear; moderately divided 0.1–4 mm wide; non-imbricate; flat to subconvolute; margins starting to brown at tips. **Upper surface** yellow-green; epruinose and shiny, smooth and becoming rugose and blackening towards older portions of the thallus. **Lower surface** pale brown; rhizines brown, occurring frequently. **Apothecia** moderate, sessile, disks brown, margins subconvex and slightly crenate. **Ascospores** ellipsoid, non-septate, colorless;  $6-7 \times 4-5 \mu\text{m}$ . **Pycnidia** infrequent to frequent, sunken below upper cortex, black.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: psoromic acid (major), 2-O-demethylpsoromic acid (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow, C-, KC-, P+ dark yellow; UV-.

**ECOLOGY AND DISTRIBUTION.** – The chemically unusual *X. psoromifera* is rarely found in Colorado. Based on available data (COLO Herbarium, CNALH 2016), only two collections to date have been made in the state on the eastern slope plains (Figure 2). It is most commonly found in the southwestern North America (CNALH 2016, Hale 1990, Nash and Elix 2004).

**NOTES.** – *Xanthoparmelia psoromifera* is considered to be the non-isidiate counterpart of *X. lavicola* (Figure 8), and besides reproductive structures, the two resemble one another morphologically and chemically. Both are the only known psoromic acid-containing *Xanthoparmelia* species in Colorado, and occur rarely in the state.





**Figure 17.** *Xanthoparmelia stenophylla* forms tight mats, often in rosettes. Its loose adnation results in a high morphological resemblance to *X. wyomingica*.

*Additional specimens examined.* – **U.S.A. COLORADO.** BENT CO.: vicinity of Raven's Nest, E on Rd. T from Hwy 101S and S on Route 16, 6.vi.2015, *E.A. Tripp* 5656 (COLO-L-0051313). LAS ANIMAS CO.: Comanche National Grassland, vicinity of Picketwire Canyon and Withers Campground, above (W) Purgatory River, 5.vi.2015, *E.A. Tripp* 5630 (COLO-L-0051253).

*Xanthoparmelia stenophylla* (Ach.) Ahti & D. Hawksw., *Lichenologist* 37: 363. 2005.  $\equiv$  *Parmelia conspersa* var.  $[\beta]$  *stenophylla* Acharius, *Methodus* (Acharius) 206. 1803.  $\equiv$  *Parmelia stenophylla* (Ach.) Heugel, *Corresp. Naturf. Ver. Riga* 8: 109 1855. **TYPE:** Sweden?, "Habitat ad montes" [*fide* protologue], *s.d.*, *s.c.* (H-ACH [9502092] [image!], lectotype designated by Hale (1990: 192); BM-ACH 607[n.v.], isoelectotype).

**FIGURE 17.**

**DESCRIPTION.** – **Thallus** orbicular; adnate to loosely adnate; saxicolous. **Lobes** irregular; 0.5–1.5 cm wide; heavily imbricate; at times convolute; blackening at margins, at times crenate. **Upper surface** yellow-green; smooth, shiny. **Lower surface** dark brown; rhizines black. **Apothecia** moderately occurring, sessile, disks light to dark brown, margins somewhat convolute. **Ascospores** absent in Colorado material. **Pycnidia** occurring moderately, sunken below upper cortex, black.

**CHEMISTRY.** – Upper cortex: usnic acid (major); medulla: salazinic acid (major). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ red. C-, KC-, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia stenophylla* is generally found at medium to high elevations ( $\geq 2134$  m, 7000 ft) in the state. Colorado material has been collected primarily in mountainous terrain on the eastern slope of the Rocky Mountains (Figure 2).

NOTES. – This species is a member of the diverse salazinic acid-containing group in Colorado that can be challenging to identify in the field. While *Xanthoparmelia stenophylla* shares numerous features (including narrow lobes and being loosely adnate to substrates) with *X. wyomingica* (Figure 20), one can differentiate the former by its much less convoluted, slightly broader lobes and overall flat, mat-like growth form. It is also more likely to be found growing on rocks (albeit somewhat loosely among rocks) whereas *X. wyomingica* is more likely to be found growing on loose pebbles or soil.

There has been some dispute over the nomenclatural validity of the name *Xanthoparmelia stenophylla* over the past several decades (Ahti and Hawksworth 2005, Hale 1990). This has resulted in collections of this species being identified under different names, which in turn has led to inconsistent herbaria filing. Ahti et al. (2005) resolved the issue and provided the combination in *Xanthoparmelia*, but it should be noted that many herbaria have yet to update specimen names, which are still filed under *X. somloënsis*.

*Additional specimens examined.* – **U.S.A. COLORADO.** BOULDER CO.: 0.8 mi S of Eldora, S shore of Lake Eldora, 9000 ft, 26.x.1952, W.A. Weber s.n. (COLO-L-0047987); 1 mi SE of Science Lodge and ca. 8 mi N of Nederland, W of Peak to Peak Hwy, 9500 ft, 17.v.1958, S. Shushan s.n. (COLO-L-004993). EL PASO CO.: N slope of Pikes Peak, 13300 ft, 1.viii.1955, S. Shushan s.n. (COLO-L-0048034). LARIMER CO.: Mummy Range, SE of Lawn Lake, base of Mummy Mountains, 3316–3365 m, 19.vi.1962, R.A. Anderson 2074 (COLO-L-0047505); 8.0 mi WSW of Loveland, Cottonwood Canyon, 7000 ft, 5.iv.1952, M.L. Matton s.n. (COLO-L-0048018); Estes Park, 9 mi SE of, or 14 mi NW of Lyons, off of Denver Highway, 7500 ft, 26.vii.1949, W. Kiener 24819 (COLO-L-0048031); Trail Ridge, N of Toll Memorial, 11800 ft, 27.viii.1962, R.A. Anderson s.n. (COLO-L-0048012). COUNTY UNKNOWN: C.L. Hayward s.n. (COLO-L-0048260).

*Xanthoparmelia subdecepiens* (Vain. ex Lynge) Hale, Phytologia 28: 489. 1974.  $\equiv$  *Parmelia subdecepiens* Vain. ex Lynge, Rev. Bryol. Lichenol. 10: 89. 1937. **TYPE: SOUTH AFRICA.** CAPE PROVINCE: Klapmuts, *P. van der Byl* s.n. (TUR [image!], holotype).

**FIGURE 18.**

**DESCRIPTION.** – **Thallus** adnate to substrate; saxicolous. **Lobes** irregular; moderately to deeply divided, 1.0–3.0 cm wide; separate to slightly imbricate; occasionally inner lobes subconvolute; margins darkening; apices usually crenate. **Upper surface** yellow-green; darkening and becoming rugose with age. **Lower surface** pale brown; rhizines pale brown, occurring frequently. **Apothecia** frequent, sessile, disks light to dark brown, at times subconvex. **Ascospores** ellipsoid, non-septate, colorless;  $8\text{--}9 \times 6\text{--}7 \mu\text{m}$ . **Pycnidia** frequent, sunken below upper cortex and black.

**CHEMISTRY.** – Upper cortex: usnic acid (major), atranorin (major or trace). Medulla: 3 unidentified fatty acids (major), protoconstipatic (minor), constipatic (trace), dehydroconstipatic (trace). Spot tests: cortex: K+yellow, C-, KC-, P-; medulla: K-, C-, KC-, P-; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia subdecepiens* is common in southern California and in the mountains of Arizona and New Mexico (Hale 1990, Nash and Elix 2004). In Colorado, it occurs along the western slope at elevations ranging from 1463–2896 m (4800–9500 ft; Figure 2), particularly on mesa tops and roadsides.

NOTES. – *Xanthoparmelia subdecepiens* shares several morphological features with *X. lineola* (Figure 9), however the former is generally more loosely adnate and does not contain salazinic acid, in contrast to the latter. Diagnostic characteristics are its negative P test and the presence of atranorin, a compound that rarely occurs in Colorado *Xanthoparmelia*. For unknown reasons, we were only successful in obtaining clear and reproduceable TLC results among Colorado material following heavy spotting and, where possible, multiple runs per collection.

TLC conducted on the holotype by F.A. Brusse (annotated on 8 March 1977) indicated the presence of aliphatic acids “?”, and five unknown compounds. It can be assumed that these unknown compounds included compounds listed among the secondary metabolites above, as they were later found in a more recent TLC run of the holotype by J. Johnston. Among Colorado material at COLO, we did identify 3 aliphatic acids (constipatic, dehydroconstipatic, protocostipatic) in our TLC assays.





**Figure 18.** *Xanthoparmelia subdecipiens* resembles a number of *Xanthoparmelia* species, including *X. cumberlandia* and *X. lineola*. The unique atranorin-containing chemistry makes it unique among *Xanthoparmelia* species in Colorado.

*Additional specimens examined.* – **U.S.A. COLORADO. BOULDER CO.:** Shanahan Mesa, a colluvial fan spreading out from the base of Bear Peak, S edge of Boulder, 1900 m, 2.v.1998, W.A. Weber *s.n.* (COLO-L-0047986). **FREMONT CO.:** 5 mi SW of Coaldale, on US Hwy 50, 2591 m, 7.vi.1958, S. Shushan *s.n.* (COLO-L-0047980). **JEFFERSON CO.:** 7 mi S of Boulder, on Rocky Flats Pediment, ridge S of farm buildings, 26.vii.1973, G. Kunkel *s.n.* (COLO-L-0047962), 09.vii.1973, G. Kunkel C-32 (COLO-L-0047968), 26.vii.1973, G. Kunkel C-55 (COLO-L-0047974).

*Xanthoparmelia vagans* (Nyl.) Hale, Phytologia 28: 490. 1974.  $\equiv$  *Endocarpon vagans* Nyl., Expos. Synopt. Pyrenocarp. p. 13. 1858. **TYPE: ECUADOR:** *s.d., s.c.*, (H-NYL [H9505472] [image!], holotype).

#### FIGURE 19.

**DESCRIPTION.** – **Thallus** vagrant, usually free-growing over but not attached to soil or rocks. **Lobes** sublinear; 0.5–3.5 mm wide; somewhat convex; dark brown/ black margins; deeply divided; usually crenate at apices. **Upper Surface** yellow-green; epruinose; smooth. **Lower Surface** brown; rhizines brown, frequently occurring. **Apothecia** not seen. **Pycnidia** frequent, sunken below upper cortex, black.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: stictic acid (major), norstictic acid (minor), constictic acid (trace), cryptostictic acid (trace), unknown compound (trace). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow- dark orange, C-, KC+ pink, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – Vagrant lichens are most commonly found in steppes, tundras, deserts, and alpine regions around the world (Perez 1997, Rosentreter 1993). They are believed to be primarily wind dispersed, and their high surface to volume ratios are thought to be beneficial in water-limited



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**Figure 19.** *Xanthoparmelia vagans* resembles other vagrant Colorado *Xanthoparmelia* in lobe type and growth form. However, it is separated from those species by the stictic acid chemistry.

environments (Perez 1997, Rosentreter 1993, Weber 1977). *Xanthoparmelia vagans* is found in Colorado on both the eastern and western slopes in canyons, plains, and in mountainous areas (Figure 2). It is the only vagrant lichen known within the state to contain stictic acid.

NOTES. – *Xanthoparmelia vagans* is one of the few vagrant species in the genus occurring in Colorado. It is highly similar to *X. chlorochroa* (Figure 4) but differs by the presence of stictic acid in the medulla, which yields a K+ yellow spot test (vs. a K+ red reaction in *X. chlorochroa*, which contains salazinic acid).

*Additional specimens examined.* – U.S.A. COLORADO. BOULDER CO.: Wild Basin, NE slope of Mt. Copeland 0.5 mi S of Ouzel Lake, 11000 ft, 28.vi.1962, R.A. Anderson 2124 (COLO-L-0048070); Continental Divide, summit of Rollins Pass, 11800 ft, 22.vii.1960, S. Shushan s.n. (COLO-L-0048051); Little Royal Gorge of Como Creek, tributary to North Boulder Creek; gorge below and W of Peak-to-Peak Highway between Caribou Ranch and CU Mountain Research Station, 40.01969 -105.51417, 2713 m, 29.iv.2000, W.A. Weber s.n. (COLO-L-0048180); Niwot Ridge, E of Navajo Peak, E slope of Front Range, 3658 m, 23.ix.1956, S. Shushan s.n. (COLO-L-0048241); 1 mi SE of Science Lodge and ca. 8 mi N of Nederland, 9500 ft, 17.v.1958, S. Shushan s.n. (COLO-L-0047993); Rocky Mountain National Park, Longs Peak, Elynetum, 3200 m, 3.ix.1935, W. Kiener 3443 (COLO-L-0047511). GUNNISON CO.: Cebolla Canyon, 7.vii.1961, S. Flowers s.n. (COLO-L-48054). JACKSON CO.: Big Creek Lake, ca. 24 mi NW of Cowdrey, E slope of Park Range, 9200 ft, 29.v.1955, S. Shushan s.n. (COLO-L-0048052). LARIMER CO.: Stonewall Creek Canyon, 6100 ft, 4 mi NNW, 16.xi.1975, F.J. Hermann 26981 (COLO-L-0048024); Estes Park, 9 mi SE of, or 14 mi NW of Lyons, off Denver Highway, 7500 ft, 26.vii.1949, W. Kiener 24760 (COLO-L-0048006). SAGUACHE CO.: Rio Grande National Forest, La Garita Mountains, vicinity of Carnero Pass, 38.01667 -106.40000, 3000 m, 10.vii.1993, B. Goffinet 3358 (COLO-L-0048197).





**Figure 20.** *Xanthoparmelia wyomingica* forms rosettes similar to *X. chlorochroa*; however the lobes are less convolute than *X. chlorochroa*, and it is not entirely free-growing.

*Xanthoparmelia wyomingica* (Gyel.) Hale, Phytologia 28: 490. 1974.  $\equiv$  *Parmelia digitulata* var. *wyomingica* Gyel., Ann. Mycol. 36: 277. 1938. **TYPE:** U.S.A. WYOMING. Big Horn Mts., 19.viii.1898, T.A. Williams 316 (BP [image!], lectotype designated by Hale (1990: 226); US [00068794] [image!], isotype).

**FIGURE 20.**

**DESCRIPTION.** – **Thallus** often forming rosettes; loosely adnate to almost vagrant; saxicolous/terricolous. **Lobes** sublinear; subdichotomously branched primarily narrow, 0.5–2.0 cm wide; separate to imbricate; at times tips convolute; margins black and crenate. **Upper Surface** yellow-green; shiny, smooth. **Lower Surface** light to dark brown; rhizines light to dark brown, occurring frequently. **Apothecia** infrequent to moderately frequent; substipitate; disks light to dark brown. **Ascospores** hyaline, simple,  $6-7 \times 4-5 \mu\text{m}$ . **Pycnidia** frequent to occasional, black, sunken below upper cortex.

**CHEMISTRY.** – Upper cortex: usnic acid (major); Medulla: salazinic acid (major), consalazinic acid (minor). Spot tests: cortex: K-, C-, KC-, P-; medulla: K+ yellow to red, C-, KC-, P+ orange; UV-.

**ECOLOGY AND DISTRIBUTION.** – *Xanthoparmelia wyomingica* is most commonly found in the southern Rocky Mountains at elevations of 2743 m (9000 ft) and higher (Eversman 1995, Hale 1990). It is a species that prefers arid habitats and often co-occurs with *X. chlorochroa* (Figure 2).

**NOTES.** – *Xanthoparmelia wyomingica* is potentially confusable with *X. chlorochroa* (Figure 3), *X. coloradoensis* (Figure 4), and *X. lineola* (Figure 9) because all four are similar chemically. However, *X. wyomingica* differs from *X. coloradoensis* and *X. lineola* in that it occasionally grows on loose pebbles and/or soil instead of rock. In addition, while *X. chlorochroa* is fully vagrant and usually lacks apothecia, presence

of sexual structures in *X. wyomingica* is comparatively more frequent. *Xanthoparmelia chlorochroa*, *X. coloradoensis*, and *X. lineola* are also generally found at lower elevations.

*Additional specimens examined.* – **U.S.A. COLORADO.** BOULDER CO.: Windy Gap, ca. 7 mi NW of Nederland (ca. 1 mi NW of Caribou), 9600 ft, 5.vii.1958, R.A. Pursell 3299 (COLO-L-0048063); Roosevelt National Forest, Mt. Audubon, 4.5 mi WNW of Ward, 40°6'10"N 105°35'15"W, 11800 ft, 30.vii.1967, R.S. Egan El-709 (COLO-L-0048068); 5 mi. NW of Eldora on trail from 4<sup>th</sup> of July Canyon to Arapahoe Glacier, 10000–11000 ft, 20.viii.1957, S. Shushan s.n. (COLO-L-0047999); Niwot Ridge, Front Range between Ward, 3505–3658 m, 14.vii.1994, W.A. Weber s.n. (COLO-L-0048174); S side of Route 103/Riverside Drive, just E of Raymond, ~100 m uphill from Rd., 40.16026 -105.44878, 2365 m, 8.xi. 2014, E.A. Tripp 5131 (COLO-L-0050951); City of Boulder Open Space, Bergheim-Wood Property, along Mesa Trail, approx. 360 ft. NW of McClintock Upper Trail, 39.990579° -105.286879°, 6014 ft, 29.vi.2015, V. Diaz 30 (COLO-L-0055846); City of Boulder Open Space, Circle of Friends Property, along Mount Sanitas Trail approx. 0.4 mi from trailhead, 40.025633° -105.300146°, 5931 ft, 10.vii.2015, V. Diaz 52 (COLO-L-0055831). Clear Creek Co.: Summit Lake, Mount Evans, 5.vii.1990, 3901 m, W.A. Weber s.n. (COLO-L-0047580); 400 yards E of Summit Lake near Mt. Evans, 12780 ft, 4.ix.1951, S. Shushan s.n. (COLO-L-0047976); SW of Georgetown, along road to Argentine Pass, 7.6 km from Guanella Pass Rd., 39.66667 -105.75000, 1036 m, 30.vii.1975, R.A. Anderson s.n. (COLO-L-0048253). CUSTER CO.: South Colony Creek, 11700 ft, 8.viii.1941, W. Kiener 10281 (COLO-L-0047964); Humbolt Peak, 13000 ft, 28.viii.1938, W. Kiener 9427 (COLO-L-0047970); South Colony Creek basin, 3566 m, 8.vii.1941, W. Kiener 10282 (COLO-L-0048247). El Paso Co.: summit of Pikes Peak, 14100 ft, 1.viii.1955, S. Shushan s.n. (COLO-L-0048028]. Grand Co.: Never Summer Mountains, Mt. Richthofen, 3414–3658 m, 16.viii.1962, R.A. Anderson 3386 (COLO-L-0048265); 1 mi N of Kremmling, off Highway 40, 40.08000 -106.41000, 2287 m, 31.viii.2011, R. Rosentreter 17385 (COLO-L-0048271); Frazer Experimental Forest, above Fool Creek, 3505 m, 1.viii.1953, W.A. Weber s.n. (COLO-L-0048295). GUNNISON CO.: trail along Copper Creek to summit of Conundrum Pass, Elk Mountains, ca. 10 mi NE of Gothic, 39.00300 -106.94200, 3871 m, 4.viii.1955, W.A. Weber s.n. (COLO-L-0048289). JACKSON CO.: summit of Flattop Mountain, headwaters of Gold Creek, Park Range S of Mount Zirkel, 3658 m, 29.vii.1956, S. Shushan s.n. (COLO-L-0048283). LARIMER CO.: Beaver Meadows, 2576 m, 16.ix.1962, R. A. Anderson 3718 (COLO-L-0048248); Larimer, Neota Wilderness, SE of Cameron Pass of Highway 14, near twin knobs on S side of Coral Creek drainage, 7 mi in on Long Draw Rd., 3414m, 20.viii.1992, J.K. Nelson 1389 (COLO-L-0048254); Neota Wilderness, southeast of Cameron Pass of Highway 14, summit of Mt. Neota, 3566 m, 8.viii.1992, J. K. Nelson 1222 (COLO-L-0048307). PARK CO.: Hoosier Ridge, E of Hoosier Pass, between Alma and Breckenridge, 3505–3810 m, 10.vii.1959, S. Shushan s.n. (COLO-L-0048242); E end of Hoosier Ridge, ca. 11 mi N of Fairplay, 3962 m, 8.vii.1956, S. Shushan s.n. (COLO-L-0048266).

#### EXCLUDED NAMES (RECOGNIZED AS CURRENT NAMES BUT NOT REPRESENTATIVE OF SPECIES THAT OCCUR IN COLORADO).

*Xanthoparmelia hypopsila* (Müll. Arg.) Hale, Phytologia 28:488. 1974. ≡ *Parmelia hypopsila* Müll. Arg., Flora (Regensburg) 70: 317. 1887. **TYPE: URUGUAY:** 1886, J. Arechavaleta y Balpardo 12 (G [G00292908] [image!], holotype).

*Xanthoparmelia taractica* (Kremp.) Hale, Phytologia 28: 485. 1974. ≡ *Parmelia taractica* Kremp., Flora 61: 439. 1878. **TYPE: ARGENTINA:** “Regiones alpinae Andium, ad terram, inter gramina” (*fide protologue*), 1872-1874, P.G. Lorentz & G. Hieronymus 27 (M [M0024921] [image!], holotype; G [G00294521] [image!], US [00069064] [image!], isotypes).

#### CONCLUSION

The overarching goal of the present study was to provide a concise and user-friendly (i.e., a product usable by a diverse audience including ecologists and land managers) synopsis of Coloradan species of usnic acid-producing *Xanthoparmelia*. This work includes dichotomous keys and an abridged taxonomic treatment of species present in the state. Our study is grounded in examination of type specimens (primarily high-resolution images), protologues, study of morphology, study of anatomy, and TLC assays. This work contributes a readily accessible means of identifying species based on morphology and chemistry, however



molecular data are needed to further assess the degree to which these species and chemical groups are or are not monophyletic. It provides a foundation on which to build further information regarding the ecology and evolution of lichens of the southern Rocky Mountains and adjacent high plains.

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# Further contributions to the Ontario flora of lichens and allied fungi, with emphasis on the Great Lakes Basin

SAMUEL R. BRINKER<sup>1</sup>

**ABSTRACT.** – Noteworthy records of forty-three lichens and allied fungi are presented based on recent collections from Ontario, Canada. Three species, *Agonimia borysthena*, *Arthonia subconveniens* (on *Ricasolia quercizans*) and *Lecanographa abscondita* are reported for the first time from North America. Eleven species, *Erythricium aurantiacum* (on *Physcia millegrana*), *Hypotrachyna showmanii*, *Leptogium arsenei*, *Opegrapha rupestris* (on *Bagliettoa*), *Pronectria tibellii* (on *Cladonia pocillum*), *Punctelia missouriensis*, *Thelidium zwackhii*, *Tremella imshaugiae* (on *Imshaugia aleurites*), *Verrucaria bryoctona*, *Vezdaea schuyleriana* and *Vouauxiella lichenicola* (on *Lecanora*) are reported for the first time from Canada. Eleven species, *Absconditella sphagnum*, *Agonimia gelatinosa*, *Didymocyrtis xanthomendozae* (on *Xanthomendoza hasseana*), *Distopyrenis americana*, *Lichenochora obscuroides* (on *Phaeophyscia pusilloides* and *P. sciastra*), *Paranectria oropensis* (on *Lecanora* and *P. rubropulchra*), *Pertusaria sommerfeltii*, *Raesaenenia huuskonenii* (on *Bryoria fuscescens*), *Stereocaulon depreaultii*, *Thrombium epigaeum* and *Trichonectria rubefaciens* (on *Aspicilia*) are reported as new to Ontario. Details on 18 additional rare or otherwise rarely collected species new to various counties and districts of the province are also provided. These include: *Abrothallus microspermus* (on *Flavoparmelia caperata*), *Ahtiana aurescens*, *Athelia arachnoidea* (on *Physcia millegrana*), *Blennothallia crispa*, *Chaenothecopsis brevipes* (on *Inoderma byssaceum*), *C. rubescens* (on *I. byssaceum*), *Cladonia dimorphoclada*, *Corticifraga fuckelii* (on *Peltigera evansiana*), *Didymocyrtis cladoniicola* (on *Cladonia*), *Hypotrachyna revoluta*, *Lepra panyrga*, *Marchandiomyces corallinus* (on *Parmelia squarrosa* and *Physcia thomsoniana*), *Muellerella hospitans* (on *Bacidia rubella*), *Refractohilum peltigerae* (on *Peltigera evansiana*), *Reichlingia leopoldii*, *Sarcosagium campestre*, *Steinia geophana* and *Vezdaea acicularis*.

**KEYWORDS.** – Appalachian-Great Lakes Region, biogeography, floristics, North America, range extensions, rare species.

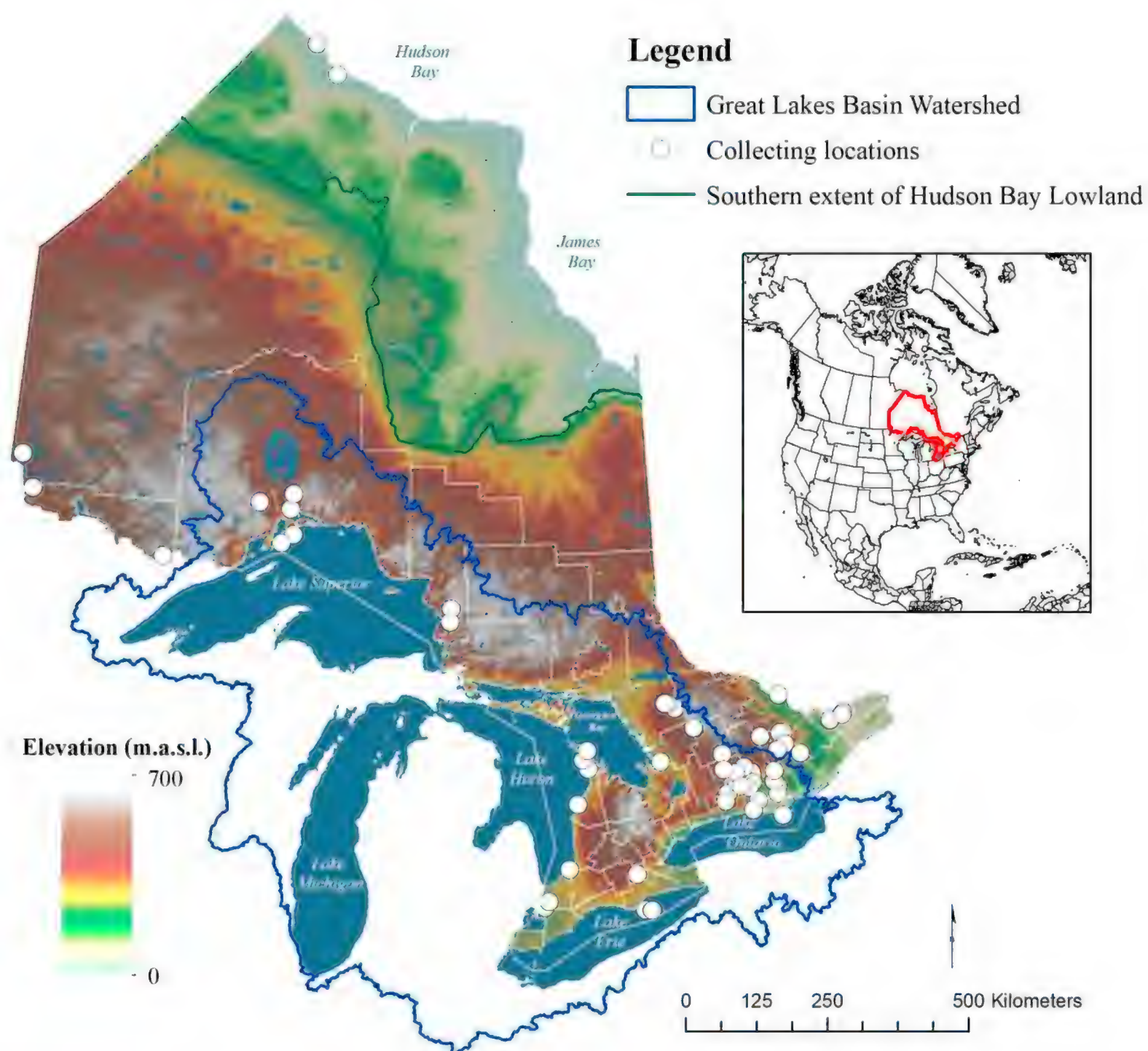
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## INTRODUCTION

Lichens and lichenicolous fungi continue to be added to the Ontario flora at a high rate (Brinker 2020). This paper continues a series of newly reported, rare, or notable range extensions for lichens and allied fungi from Ontario, Canada, with an emphasis on the Great Lakes Basin. The Great Lakes Basin is noted for containing the greatest diversity of species in Canada and is one of the most diverse ecoregions in North America (Comer et al. 2003). It contains the largest freshwater ecosystem in the world, storing 20% of the world's supply of surface freshwater and together they are among the world's 15 largest lakes. The Ontario Great Lakes Basin spans an area of 230,000 km<sup>2</sup>, extending from its southern limits at Lake Erie (42°N) north to its head waters, which originate north of Lake Nipigon (50°N). Ontario includes portions of all Great Lakes except Lake Michigan. The land that encompasses the Ontario Great Lakes Basin is about one-third of the province, part of the Ontario Shield and Mixedwood Plains terrestrial ecozones (Crins et al. 2009). In terms of lichen diversity, however, the region seems to be understudied as new species described

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**Figure 1.** Collecting locations of the author within the Province of Ontario, Canada, cited in the text.

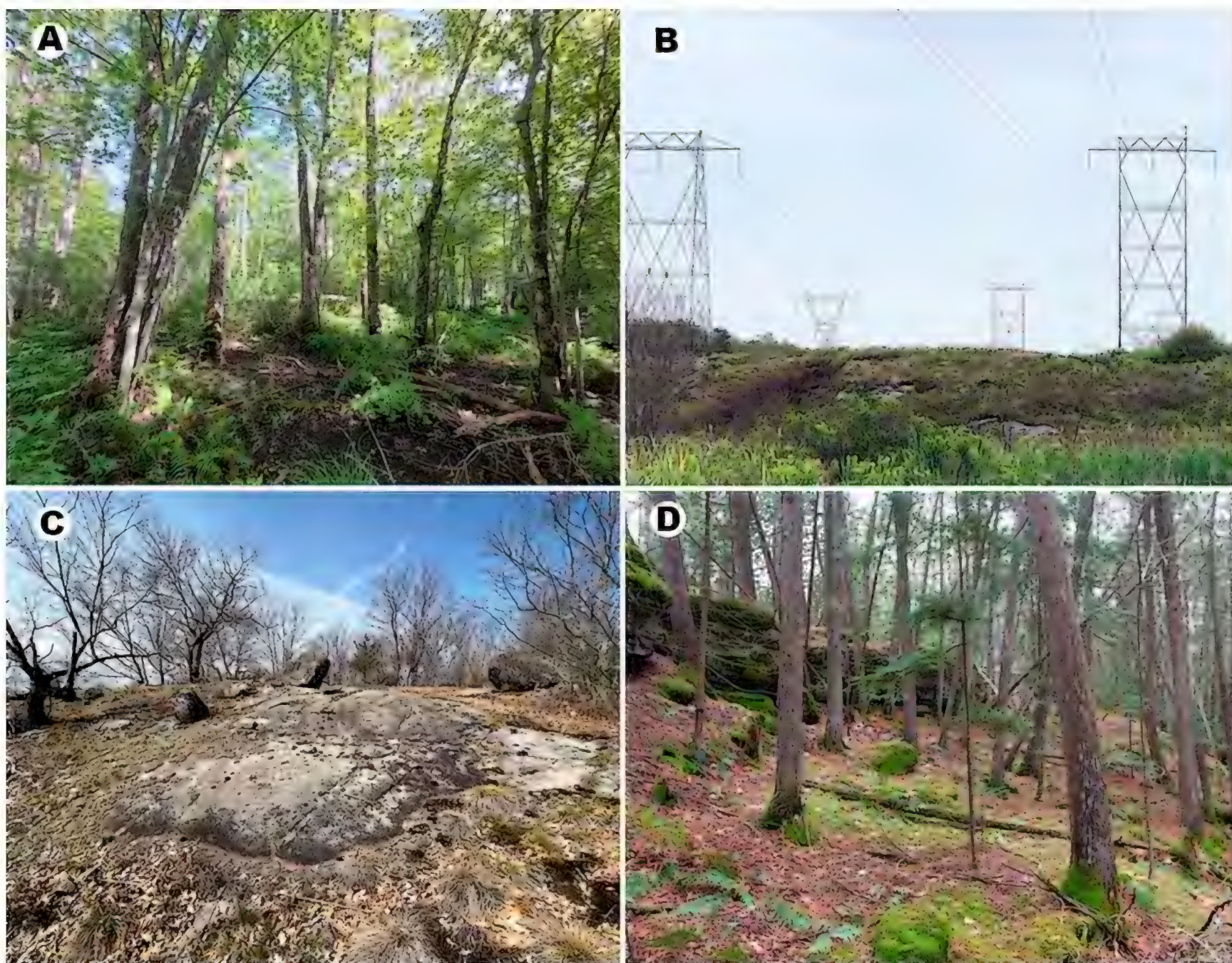
from the region (e.g., Henssen 1969) lack recent records, and new distributional records and range extensions continue to be found. Lichenological fieldwork in the province has steadily increased over the last decade though, a result of surveys of protected areas (Brodo et al. 2013, Lewis 2019, McMullin & Lendemer 2016), regional assessments (Brodo et al. 2021, Maloles et al. 2018, McMullin et al. 2018), field research (Allen & McMullin 2019, McMullin et al. 2016), focused conservation status assessments (COSEWIC 2015, 2016), and other discoveries of new species to science (Brinker et al. 2022, McMullin et al. 2020).

In this paper three species are reported as new to North America, eleven species are reported as new to Canada and eleven are reported as new to Ontario. A further eighteen rare or seldom collected species are also discussed. Most collections were made in the Great Lakes Basin during routine fieldwork by the author mainly during COVID-19 travel restrictions and review of personal specimen backlogs. With the present contribution, I hope to raise awareness of previously neglected species of lichens and allied fungi, and to encourage further fieldwork in the region. Notes on the ecology (including substrate preference), distribution, and status of the species are provided where possible.

## MATERIALS AND METHODS

The study material was collected during routine floristic surveys carried out mainly between the years 2019 and 2022 and mainly from the Great Lakes Basin of Ontario (Fig. 1). In addition to the major habitats examined in the previous paper by the author (Brinker 2020), several additional habitats were the





**Figure 2.** Representative photographs of four habitats evaluated during this study in the Ontario portion of the Great Lakes Basin in addition to those examined in Brinker (2020). **A**, deciduous swamps. **B**, electric power transmission corridors. **C**, acidic bedrock barrens. **D**, upland limestone coniferous forests.

focus of this work including: deciduous swamps, electric power transmission corridors, acidic bedrock barrens, and upland limestone coniferous forests (Fig. 2).

External morphology of dried specimens was studied with a dissecting microscope. Sections of the ascomata and thalli were made by hand using a razor blade, and then mounted in water. Anatomical studies of the thallus and ascomata were carried out using bright-field microscopy. Standard chemical spot tests and ultraviolet light followed Brodo et al. (2001). These include para-phenylenediamine dissolved in ethyl alcohol (PD), sodium hypochlorite (C), 10% potassium hydroxide (K), and Lugol's iodine (I). Thin-layer chromatography was conducted by James Lendemer in Solvents A or C following the methods outlined by Lendemer (2011a) and with Solvent C using the ratio of 200:30 toluene:glacial acetic acid.

Distribution maps were created using ESRI ArcMap 10.3.1 software and data used to generate these maps were obtained from the Consortium of North American Lichen Herbaria (CNALH), the herbarium of the Canadian Museum of Nature and relevant literature for each species where verified records exist. Attempts were made to remove records that appeared erroneous due to mistakes such as digitization errors or out of range/or likely misidentifications. Herbarium codes follow Index Herbariorum (Thiers 2022), and specimens were deposited in the following herbaria: Meise Botanic Garden (BR), Canadian Museum of Nature (CANL), Musée national d'histoire naturelle (LUX), New York Botanical Garden (NY), University of Oslo (O), Oregon State University (OSC), as well as the private herbarium of the author (hb. Brinker).



## RESULTS

A total of 43 species are reported from Ontario representing 38 genera. Non-lichenized and lichenicolous fungi account for 20 species of the total reported here. Three taxa are not on the most recent checklist of North American lichenized fungi biota (Esslinger 2021) and are herewith new or confirmed for North America: *Agonimia borysthenica*, *Arthonia subconveniens* and *Lecanographa abscondita*. The first published records from Canada for six lichens and five lichenicolous fungi include: *Erythricium aurantiacum*, *Hypotrachyna showmanii*, *Leptogium arsenei*, *Opegrapha rupestris*, *Pronectria tibellii*, *Punctelia missouriensis*, *Thelidium zwackhii*, *Tremella imshaugiae*, *Verrucaria bryoctona*, *Vezdaea schuyleriana* and *Vouauxiella lichenicola*. A total of five lichens, five lichenicolous fungi and one non-lichenized fungus are new for the Province of Ontario: *Absconditella sphagnorum*, *Agonimia gelatinosa*, *Didymocyrtis xanthomendozae*, *Distopyrenis americana*, *Lichenochora obscuroides*, *Paranectria oropensis*, *Pertusaria sommerfeltii*, *Raesaenenia huuskonenii*, *Stereocaulon depreaultii*, *Thrombium epigaeum* and *Trichonectria rubefaciens*. Notes on an additional nine lichens and nine lichenicolous fungi that are rare or otherwise seldom reported from Ontario are also provided: *Abrothallus microspermus*, *Ahtiana aurescens*, *Athelia arachnoidea*, *Blennothallia crispa*, *Chaenothecopsis brevipes*, *C. rubescens*, *Corticifraga fuckelii*, *Cladonia dimorphoclada*, *Didymocyrtis cladoniicola*, *Hypotrachyna revoluta*, *Lepra panyrga*, *Marchandiomyces corallinus*, *Muellerella hospitans*, *Refractohilum peltigerae*, *Reichlingia leopoldii*, *Sarcosagium campestre*, *Steinia geophana* and *Vezdaea acicularis*.

The reports presented below are arranged alphabetically by genus and species in order of their relative significance: new to North America (\*\*\*), new to Canada (\*\*), new to Ontario (\*), and additional noteworthy provincial/Great Lakes Basin collections. The notes presented for many species include details on the previously known North American distribution. Lichenicolous fungi are denoted by a dagger (†); nonlichenized fungi traditionally treated with lichens are denoted by a plus (+). Nomenclature follows Esslinger (2021).

### SPECIES NEW TO NORTH AMERICA

The following three species were not included in Esslinger (2021) and are newly reported to the North American lichen biota.

#### \*\*\**Agonimia borysthenica* L.V. Dymytrova, O. Breuss & S.Y. Kondr.

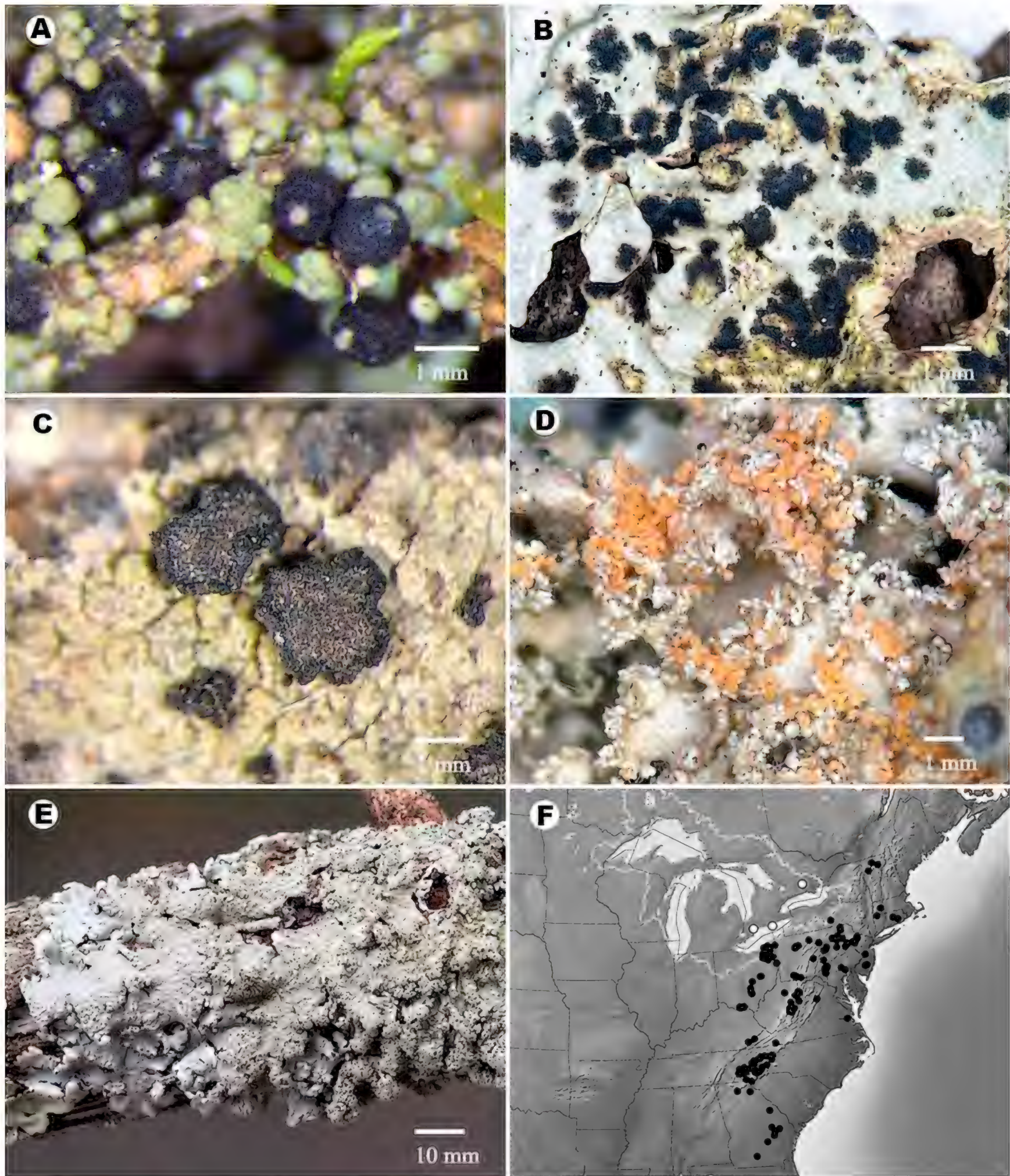
#### FIGURE 3A.

This species was described from eastern Europe (Ukraine) by Dymytrova et al. (2011) and has since been reported from Switzerland, and several additional locations in the Ukraine (Dymytrova et al. 2012). As with several other members of the genus, *Agonimia borysthenica* is corticolous, growing among mosses and on mossy bark at the bases of old trees, particularly *Quercus* and *Fraxinus* in locally humid old-growth woodlands (Dymytrova et al. 2011, 2012). These new locations broaden the distribution of the species considerably to include eastern North America. It is noteworthy that the collections reported here were from mature, relatively undisturbed hardwood forest remnants.

Among the eight-spored corticolous species of *Agonimia*, *A. borysthenica* is distinctive in having a thick, granular, greenish grey thallus, very small, ovoid to pyriform, sessile to one-third immersed perithecia 0.7–0.25 mm in width, and muriform, ellipsoid ascospores  $40\text{--}55\text{--}(75) \times 18\text{--}24\text{ }\mu\text{m}$  (Breuss 2020, Dymytrova et al. 2011). Other corticolous members of the genus with eight-spored asci reported from North America include *A. allobata* (Stizenb.) P. James and *A. flabelliformis* Halda, Czarnota & Guzow-Krzemińska. *Agonimia allobata* is distinguished from *A. borysthenica* by narrower and smaller ascospores ( $30\text{--}35 \times 10\text{--}15\text{ }\mu\text{m}$ ; Orange & Purvis 2009). *Agonimia flabelliformis* differs in thallus morphology, having finger-like to coralloid aggregations of goniocysts, and smaller ascospores ( $20\text{--}45 \times 12\text{--}20\text{ }\mu\text{m}$ ; Waters & Lendemer 2019). One additional species with eight-spored asci is known from North America, *A. gelatinosa* (Ach.) M. Brand & Diederich, but differs in its ecology, growing over soil or moss on rock, or directly on rock, and has smaller ascospores ( $30\text{--}50 \times 15\text{--}20\text{ }\mu\text{m}$ ; Breuss 2020).

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: 9 km NE of Plevna, 4.5 km W of Ompah, 800 m E of Mosque Lake, upland *Acer saccharum* – *Tilia americana* – *Populus tremuloides* deciduous forest on S-facing slope with siliceous rock outcrops, 12.ix.2020, corticolous on bark of *T. americana*, S.R. Brinker 8562 (CANL, hb. Brinker; conf. O. Breuss, by photographs). **PRINCE EDWARD**





**Figure 3.** Photographs and distribution map of lichens and allied fungi new to North America or Canada (white = newly reported Ontario records, black = previous collections). **A**, *Agonimia borysthenica* (Brinker 3344). **B**, *Arthonia* cf. *subconveniensi* on *Ricasolia quercizans* (Brinker 8988). **C**, *Lecanographa abscondita* (Brinker 7873). **D**, *Erythrimum aurantiacum* on *Physcia millegrana* (photo taken in situ, Brinker 8898). **E**, *Hypotrachyna showmanii* on twig of *Thuja occidentalis* (photo taken in situ, Brinker 9382). **F**, distribution of *H. showmanii* in North America.



CO.: St. Lawrence Islands National Park, NE side of Main Duck Island, Lake Ontario, old deciduous forest remnant adjacent to small vernal pool with *Ulmus americana*, *Quercus macrocarpa* and *Cornus sericea*, 24.ix.2013, on lower trunk of mossy *U. americana*, S.R. Brinker 3243B (NY).

\*\*\*†*Arthonia cf. subconveniens* Nyl.

FIGURE 3B.

*Arthonia subconveniens* is a lichenicolous fungus confined to *Lobaria* s.l. that produces conspicuous brownish to black, roundish ascomata on the infected host thallus (Wedin & Hafellner 1998). It has a hymenium that reacts I+ red and K/I+ blue, asci that are  $22\text{--}30 \times 14\text{--}17 \mu\text{m}$ , with (6–)8 ascospores, and ascospores that are hyaline, two-celled and  $13\text{--}15 \times 4 \mu\text{m}$  in size (Wedin & Hafellner 1998). The species was described from Brazil where it was lichenicolous on *Lobaria peltigera* (Delile) Vain. In a revision of lichenicolous members of *Arthonia* on Lobariaceae, Wedin and Hafellner (1998) found *A. ricasoliae* Müll. Arg., which was described from Australia from unidentified *Lobaria* species, to be conspecific with *A. subconveniens* being similar in all aspects to that species other than having slightly smaller ascospores. The material collected during this study was lichenicolous on *Ricasolia quercizans* (Michx.) Stizenb. ( $\equiv$  *Lobaria quercizans* Michx.) with asci that were  $25\text{--}32 \times 10\text{--}13 \mu\text{m}$ , 6–8-spored, and the ascospores were two-celled,  $10\text{--}13 \times 2.5\text{--}4 \mu\text{m}$  in size.

While this material has slightly smaller ascospores than previously reported, it otherwise could not be separated morphologically from the published description of the type specimen, particularly when incorporating the broader concept of the species proposed by Wedin and Hafellner (1998) that includes *A. ricasoliae*. The collections cited below are tentatively assigned to *A. subconveniens* since no other similar taxa are known. According to a query of CNALH, this species was previously documented in North America from two specimens on *R. quercizans*, one identified by R.C. Harris from Ontario (Lewis 963, NY) and one from North Carolina (Hollinger 24006, NY). However, neither of these records has been published and thus the species has not been added to the North America checklist (Esslinger 2021). Therefore, it is reported here for the first time from North America. It is plausible that the material on *R. quercizans* represents an undescribed taxon since the species was described from a neotropical *Lobaria* host. More collections are clearly needed for taxonomic resolution. Hopefully this report will stimulate others to locate additional material from *R. quercizans*.

*Specimens examined.* – **CANADA. ONTARIO.** ALGOMA DIST.: 15 km N of Montreal Lake, 11 km SE of Elton, mature *Acer saccharum*-dominated hardwoods on N-facing slope, 27.vi.2023, lichenicolous on thallus of *Ricasolia quercizans* on bark of *A. saccharum*, S.R. Brinker 10011 (CANL). LENNOX & ADDINGTON CO.: 40 km ENE of Bancroft, 2 km NE of Trout Lake, mixed forest in sheltered valley with *Thuja occidentalis*, *Fraxinus nigra*, *Betula alleghaniensis* and *Abies balsamea*, 27.viii.2021, lichenicolous on thallus of *R. quercizans* on bark of *F. nigra*, S.R. Brinker 8988 & G. Cameron (NY, hb. Brinker).

\*\*\**Lecanographa abscondita* (Th. Fr.) Egea & Torrente

FIGURE 3C.

*Lecanographa abscondita* was previously known from arctic-alpine areas of Great Britain (Scotland), Finland, central Europe, Asia, and Greenland (Stenroos et al. 2016, Wolseley 2009). In these regions it is restricted to dry, sheltered rock overhangs on slightly calcareous rock (Flakus 2007, Wolseley 2009). Here, it had a similar ecology, where it grew on humid, sheltered, near-vertical faces of large boulders on north-facing talus slopes with other species with western and arctic-alpine affinities such as *Baeomyces placophyllus* Ach., *Arctoparmelia subcentrifuga* (Oxner) Hale, *Pannaria tavaresii*, P.M. Jørg. and *Scytinium gelatinosum* (With.) Otálora, P. M. Jørg. & Wedin (Brinker unpublished data). In addition to being the first collections documented from North America, the genus *Lecanographa* Egea & Torrente is reported for the first time from Ontario. *Lecanographa abscondita* can be differentiated from other temperate members of the genus found in the Northern Hemisphere by its ecology, C+ red thallus and four-celled,  $5\text{--}7\text{--}(8) \mu\text{m}$  wide ascospores that become brown and ornamented with age (Wolseley 2009).

*Specimens examined.* – **CANADA. ONTARIO.** THUNDER BAY DIST.: Ruby Lake Provincial Park, Doghead Mountain, 3 km SE of Nipigon, 1.4 km NW of Ruby Lake, N-facing talus slope with scattered *Picea mariana* and *Betula papyrifera* surrounded by boreal forest, 23.vii.2019, saxicolous on partially sheltered talus boulders, S.R. Brinker 7873 (BR, CANL; det. D. Ertz); Kama Hills Conservation



Reserve, 22 km NE of Nipigon, 6 km W of Blair Lake, N-facing treed talus slope in mixed boreal forest with *B. papyrifera*, *Abies balsamea* and *P. mariana*, saxicolous on vertical talus boulder, 15.vi.2023, S.R. Brinker 9858 (hb. Brinker).

#### SPECIES NEW TO CANADA

As noted previously by Brinker (2020), it can be difficult to ascertain what constitutes a first report for Canada as there is no formal published checklist of Canadian lichens and allied fungi. However, based on a review of relevant published literature dealing with Canadian lichens and consulting the CNALH, the following six lichens and five lichenicolous fungi appear to represent either the first Canadian collections or first published records.

#### **\*\*†*Erythricium aurantiacum* (Lasch) D. Hawksw. & A. Henrici**

**FIGURE 3D.**

Recent insights derived from molecular sequence data have resulted in the generic placement of the teleomorph of *Marchandiomyces aurantiacus* (Lasch) Diederich & Etayo, *Marchandiobasidium auranticum* Diederich & Schultheis, in the genus *Erythricium* J. Erikss. & Hjortstam (Hawksworth & Henrici 2015). This species is rarely mentioned in North American literature, having first been reported from California (Diederich & Lawrey 2007, as *M. aurantiacum*) and more recently from Ohio (Curtis 2019).

*Erythricium aurantiacum* can be distinguished most easily from other similar basidiomycetous lichenicolous fungi by the pale orange rather than pastel pink to coral red bulbils on species of *Physcia* (Schreb.) Michx (Diederich et al. 2003, as *M. aurantiacum*). The specimen reported here was lichenicolous on *P. millegrana* Degel. This is the first report for Canada.

*Specimen examined.* – **CANADA. ONTARIO. NORFOLK CO.:** Long Point National Wildlife Area, N shore of Lake Erie, Squires Ridge, 13.5 km S of Turkey Point, *Quercus rubra* woodland on sandy ridgetop with *Q. muehlenbergii* and *Ostrya virginiana*, 22.vii.2021, lichenicolous on *Physcia millegrana* on bark of *Q. rubra*, S.R. Brinker 8898 (hb. Brinker).

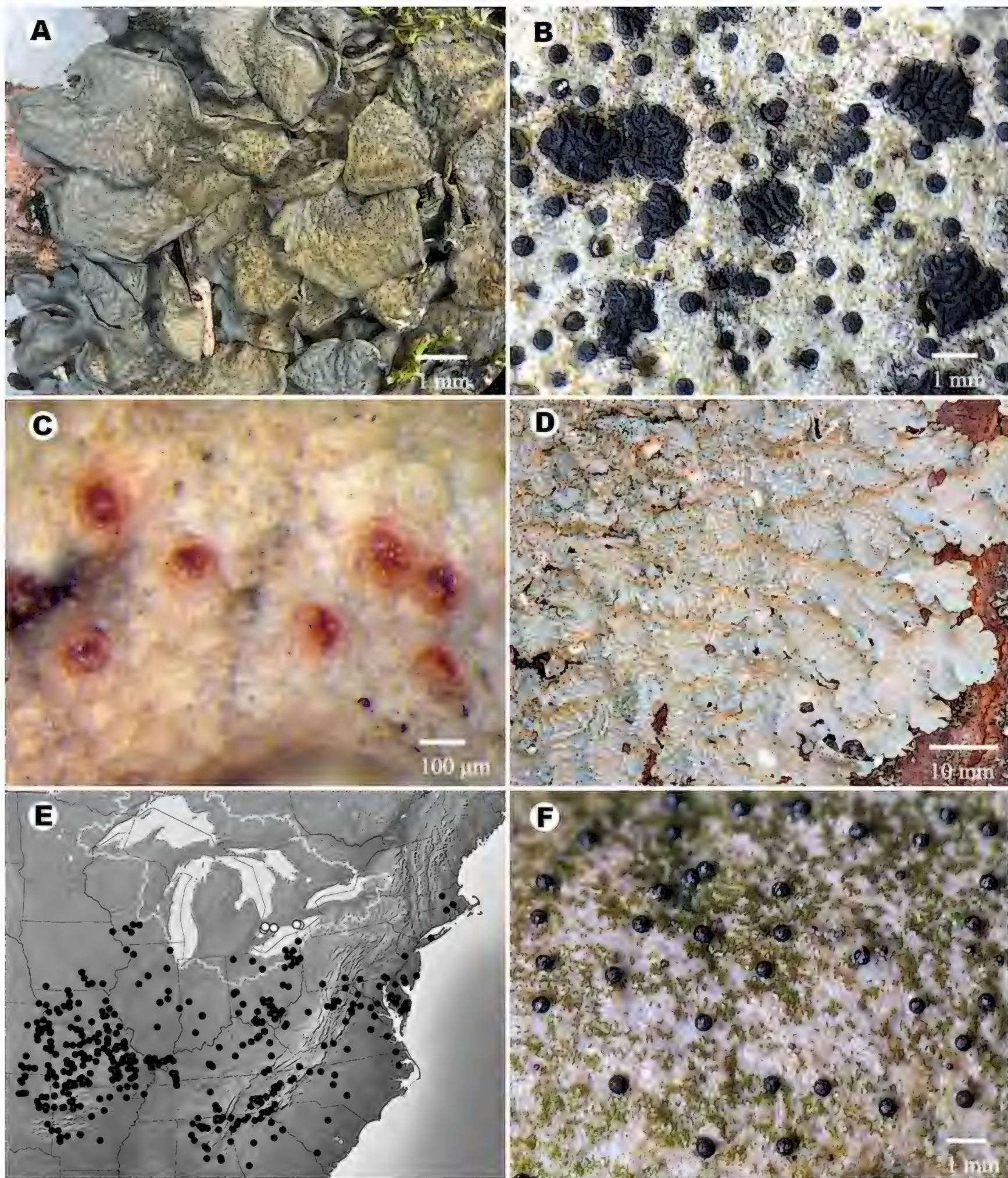
#### **\*\**Hypotrachyna showmanii* Hale**

**FIGURES 3E & 3F.**

*Hypotrachyna showmanii* is an uncommon but widespread eastern North American endemic presently considered globally rare (NatureServe 2022). However, this status should be reviewed in light of these new records. As pointed out by Lendemer and Allen (2020) it has long been overlooked because it resembles other pustulose species and often grows intermixed as scattered thalli in corticolous communities crowded with numerous other blue-grey foliose lichen species. It was mentioned in a list of lichens for Ontario by Newmaster and Ragupathy (2012) without specimen citation and there seems to be no basis for its inclusion since no other specimens from the province are known to exist. The collections reported here are the first confirmed records from Canada.

It can be recognized by its blue-grey thallus with adnate lobes, maculate lobe tips and coarse, laminal pustules that initiate as small bumps in the upper cortex and inflate to become bubble-like to 0.1–0.5 mm in diameter with constricted bases, congregating into clusters which eventually break down into coarse shingle-like fragments (Lendemer & Allen 2020). In Ontario, the species is most likely to be confused with *Hypotrachyna revoluta* (Flot.) Hale or *H. afrorevoluta* (Krog & Swinscow) Krog & Swinscow, both recently reported for Ontario (Brinker 2020). *Hypotrachyna revoluta* can be distinguished from *H. showmanii* in producing farinose soredia which are mainly confined to lobe tips that are often elongate and ascending, whereas *H. showmanii* produces esorediate pustules over its entire thallus (Lendemer & Harris 2006). Like *H. showmanii*, *H. afrorevoluta* produces pustules but they break down becoming sorediate as they erode and flake off to reveal the black lower cortex, whereas pustules formed on *H. showmanii* are esorediate (though if crushed or pressed after collecting may appear sorediate) and do not flake off to reveal the lower cortex (Lendemer & Allen 2020). In addition, the lobe tips of *H. afrorevoluta* are emaculate and often revolute, whereas those of *H. showmanii* are maculate and not revolute (Hinds & Hinds 2007). Another pustulate species *H. showmanii* could be confused with in the study area is *Myelochroa aurulenta* (Tuck.) Elix & Hale. The latter differs in producing soredia that form from the breakdown the cortex or laminal pustules which eventually expose a yellow medullary pigment





**Figure 4.** Photographs and distribution map of lichens and allied fungi new to Canada (white = newly reported Ontario records, black = previous collections). **A**, thallus lobes of *Leptogium arsenei* (Brinker 5064A). **B**, *Opegrapha rupestris* on *Bagliettoa* sp. (Brinker 9304). **C**, *Pronectria tibellii* on *Cladonia pocillum* (Brinker 9204A). **D**, *Punctelia missouriensis* (photo taken in situ, Brinker 9696). **E**, distribution of *P. missouriensis* in North America. **F**, *Thelidium zwackhii* (photo taken in situ, Brinker 8746).



(Hinds & Hinds 2007), whereas the pustules formed on *H. showmanii* thalli do not erode to form soredia and the medulla is always white (Lendemer & Allen 2020).

*Specimens examined.* – **CANADA. ONTARIO. MIDDLESEX CO.:** 18 km W of West Lorne, 4.5 km S of Newbury, deciduous swamp with *Acer ×freemanii*, *Ulmus americana* and *Quercus bicolor*, 23.ix.2022, corticolous on bark of *A. ×freemanii*, S.R. Brinker 9589 (hb. Brinker). **NORFOLK CO.:** Backus Woods Natural Area, 4.5 km N of Port Rowan, 4 km SE of Walsingham, edge of young scrubby mixed woods, 29.i.2023, corticolous on *Picea glauca* twig, S.R. Brinker 9733 (CANL). **PETERBOROUGH CO.:** North River, 7.5 km NE of Havelock, lowland mixed hardwood forest with *Thuja occidentalis*, *Fraxinus pennsylvanica* and *Tsuga canadensis*, 07.vii.2022, corticolous on twigs of downed *T. occidentalis*, S.R. Brinker 9382 (NY, hb. Brinker; conf. J.C. Lendemer).

**\*\**Leptogium arsenei* Sierk**

**FIGURE 4A.**

*Leptogium arsenei* occurs primarily in western and central North America where it grows on rock or less frequently at the base of trees (Jørgensen & Nash 2004). The species is disjunct in Minnesota (Wetmore 2005) and has been reported as far east as Michigan (Fryday et al. 2001) and Wisconsin (Bennett & Wetmore 2004). The collections reported here were from the bark of *Thuja occidentalis* in mature stands of locally humid, cedar-dominated coniferous forest. These are the first published reports of *L. arsenei* from Canada.

This species can be recognized by its upper surface which is slate grey (to occasionally brownish grey), wrinkled, with laminal isidia that are initially granular and then becoming cylindrical, the lower surface lacking white hairs, and very thick lobes which are 200–350(–500) µm in cross section (Jørgensen & Nash 2004). In the Great Lakes Basin, it is most likely to be confused with *Leptogium cyanescens* (Rabenh.) Körber which is the most frequently encountered isidiate *Leptogium* (Ach.) Gray in the region (Brinker unpublished data) and elsewhere in North America (Brodo et al. 2001). *Leptogium cyanescens* can also be slate grey or more commonly blue grey, but its upper surface is smooth, lacking distinct wrinkles, and the lobes are thinner in cross section (35–100 µm; Jørgensen & Nash 2004).

*Specimens examined.* – **CANADA. ONTARIO. RAINY RIVER DIST.:** Quetico Provincial Park, 75 km SE of Atikokan, W end of portage between Emerald Lake and Plough Lake, old-growth forest with *Thuja occidentalis*, *Fraxinus nigra* and *Acer spicatum*, 18.viii.2016, corticolous on *A. spicatum*, S.R. Brinker 5261 (CANL, hb. Brinker). **THUNDER BAY DIST.:** Albert Lake Mesa Provincial Nature Reserve, 53 km WNW of Nipigon, S-side of Albert Lake, old-growth mixed boreal forest with *T. occidentalis*, *Abies balsamea*, *A. spicatum*, *Taxus canadensis* and *Betula papyrifera*, 16.vii.2016, corticolous on *T. occidentalis*, S.R. Brinker 5064A (NY).

**\*\*†*Opegrapha rupestris* Pers.**

**FIGURE 4B.**

Lichenicolous members of the genus *Opegrapha* Ach. are strongly host specific to single species or groups of closely related species (Vondrák & Kocourková 2008). *Opegrapha rupestris* forms single or small clusters of black, lirellate ascomata on species of *Bagliettoa* A. Massal. on calcareous rock (Coppins et al. 2021). It was not listed for Canada by Ertz et al. (2021) who recently published a list of lichenicolous *Opegrapha* confirmed from the country. Interestingly, Thomson (1997) mapped two records of *O. saxicola* Ach. from Newfoundland and Labrador and he considered *O. rupestris* to be a synonym of that species. However, neither Ertz et al. (2021) nor Diederich et al. (2018) included *O. saxicola* as a synonym of *O. rupestris*, and Thomson's (1997) description of the *O. saxicola* differs significantly in ecology and structure from *O. rupestris* (i.e., not lichenicolous, having a round to ellipsoid ascomata and larger spores). Therefore, the collections cited here appear to be the first confirmed reports from Canada.

Additional populations of *Opegrapha rupestris* in the Great Lakes Basin are likely to be found on dolomitic limestone outcrops with *Bagliettoa* spp., particularly along the Niagara Escarpment. In addition to its ecology, it can be identified by its four-celled ascospores measuring 14–22 × 5–8 µm, and K+ brownish red exciple (Coppins et al. 2021, Pentecost & James 2009).

*Specimens examined.* – **CANADA. ONTARIO. HASTINGS CO.:** 8.6 km SE of Tweed, 7 km N of Naphan, limestone outcrops in rich deciduous forest with *Acer saccharum*, *Ostrya virginiana* and *Tilia*

*americana*, 20.xi.2020, lichenicolous on *Bagliettoa* sp. on shaded limestone outcrop, S.R. Brinker 8685 (BR, hb. Brinker; det. D. Ertz). PETERBOROUGH CO.: Warsaw Caves Conservation Area, 12 km E of Lakefield, *Thuja occidentalis*-dominated coniferous forest with numerous moss-covered limestone boulders and outcrops, 16.xii.2021, lichenicolous on *Bagliettoa* sp. on shaded limestone outcrop, S.R. Brinker 9304 (hb. Brinker).

**\*\*†*Pronectria tibellii* Zhurb.**

**FIGURE 4C.**

This species was originally described from Alaska (Zhurbenko & Alstrup 2004) and its distribution in North America is still unclear with no other recent reports, though it has since been documented from Russia (Zhurbenko 2009). The genus is characterized by non-stromatic, immersed, pale yellow to orange or red perithecia that are KOH-, having two to eight-spored asci and smooth or ornamented, usually two-celled ascospores, and growing on lichenized fungi and algae (Rossman et al. 1999). *Pronectria tibellii* has a distinct ecology, occurring on the upper basal squamules and podetia of *Cladonia pocillum* (Ach.) O.J. Rich. and causing bleaching of the host thallus (Zhurbenko & Alstrup 2004). These are the first records from eastern North America.

The combination of its occurrence on the host thallus of *Cladonia*, its immersed, orange perithecia that are wider than 200 µm and its ornamented, two-celled ascospores less than 16 µm long distinguishes *Pronectria tibellii* from other superficially similar species (Khodosovtsev et al. 2012, Zhurbenko & Pino-Bodas 2017). *Ovicuculispora parmeliae* (Berk. & M.A. Curtis) Etayo also has orange perithecia and 2-celled ascospores although its perithecia are covered with a fine whitish pubescence and its asci produce ascospores of two kinds: macrospores that are 40–80 µm long and microspores that are 11–15 µm long (Etayo 2010). *Nectriopsis cladoniicola* M.S. Cole & D. Hawksw. can be readily distinguished by its superficial ascomata that are not immersed in the host thallus (Zhurbenko & Pino-Bodas 2017).

*Specimens examined.* – **CANADA. ONTARIO.** LAMBTON CO.: SE shore of Lake Huron, Pinery Provincial Park, 6 km S of Grand Bend, sandy *Juniperus virginiana* savanna with *Quercus velutina* and *Juniperus communis*, 4.xi.2021, lichenicolous on basal squamules of *Cladonia* sp. among mosses over sand, S.R. Brinker 9231A (CANL; conf. M. Zhurbenko from photographs). PETERBOROUGH CO.: Petroglyphs Provincial Park, 2 km N of Stony Lake, open marble barren with *Picea glauca*, *Prunus virginiana* and *Danthonia spicata* surrounded by upland mixed forest, 28.x.2021, lichenicolous on *Cladonia pocillum* basal squamules, S.R. Brinker 9204A (hb. Brinker).

**\*\**Punctelia missouriensis* Wilhelm & Ladd**

**FIGURES 4D & 4E.**

This species was described from Missouri and its distribution was thought to correspond with the Prairie Peninsula of the interior region of North America (Wilhelm & Ladd 1992). According to the authors, in that region it commonly occurred on the exposed trunks of old hardwoods, particularly oaks, or more rarely siliceous rock faces. More recent literature has since shown it is widespread in eastern North America with published records from New Jersey (Waters & Lendemer 2019), Ohio (Showman & Flenniken 2004) and Virginia (Hokinson et al. 2009). The populations reported here are among the northernmost occurrences of this species and the first records from Canada. It should be searched for elsewhere in the Carolinian Zone of southwestern Ontario where it appears to have been overlooked.

*Punctelia missouriensis* can be distinguished from the other six species of *Punctelia* found in the Great Lakes Basin by its pale brown lower surface and laminal, partially corticate, squamiform isidia often arising from pseudocyphellae, with typically fewer than ten per pseudocyphella and medulla containing lecanoric acid (Aptroot 2003, Lendemer & Noell 2018). The most frequently encountered *Punctelia* in the study area is *P. rudecta* (Ach.) Krog (S. Brinker unpublished data) which is also isidiate. It can readily be distinguished from *P. missouriensis* by its taller, branched, corticate isidia with brown tips that do not resemble coarse masses of soredia mounded in a sorolium (Lendemer & Noell 2018). *Punctelia bolliana* (Müll. Arg.) Krog is infrequently encountered and has a pale undersurface, but its thallus is lobulate, lacking isidia, and often develops heavy wrinkles and folds on older thallus portions (Brodo et al. 2001, Lendemer & Hodkinson 2010). *Punctelia appalachensis* (W.L. Culb.) Krog is another lobulate species that occurs in the Great Lakes Basin; however, the lower surface of the thallus is distinctly black (Lendemer & Hodkinson 2010), and it is rare in Ontario (Brinker 2020, Lewis & Brinker 2017). Four other sorediate members of the genus occur in the region and could be confused with *P. missouriensis*. *Punctelia caseana*



Lendemer & B.P. Hodk. is widespread but it produces finer, ecorticate soredia not resembling isidia. *Punctelia perreticulata* (Räsänen) G. Wilh. & Ladd is very rare in Ontario (Brinker unpublished data), produces fine soredia, and the upper surface is scrobiculate with pruinose lobe tips (Lendemer & Hodkinson 2010). *Punctelia borreri* (Sm.) Krog is distinct in being the only corticolous sorediate species with a black undersurface. It appears to be extremely rare in Ontario and has not been collected recently (Wong & Brodo 1992). *Punctelia stictica* (Duby) Krog is also rare and differs in its ecology, being restricted primarily to stable rockfaces along Lake Superior and Lake Nipigon (Brinker 2020) and has a black undersurface and a medulla that contains gyrophoric acid (Aptroot 2003).

*Specimens examined.* – **CANADA. ONTARIO.** LAMBTON CO.: Reid Conservation Area 8.7 km N of Wallaceburg along North Sydenham River, upland deciduous forest with *Quercus rubra*, *Q. alba* and *Ostrya virginiana*, 10.xi.2022, corticolous on bark of mature downed *Q. rubra*, S.R. Brinker 9696 (CANL); McKellar Wildlife Area, 20 km NNE of Wallaceburg, 14.5 km W of Oil Springs, lowland deciduous forest on clay plain with *Acer ×freemanii* with *Quercus* spp., 11.xi.2022, corticolous on bark of *A. ×freemanii*, S.R. Brinker 9699 (CANL). MIDDLESEX CO.: 60 km SW of London, 17.5 km NE of Thamesville, deciduous swamp with *A. ×freemanii*, *Ulmus americana* and *Cephalanthus occidentalis*, 9.xi.2022, corticolous on bark of *A. ×freemanii*, S.R. Brinker 9690 (hb. Brinker). NORFOLK CO.: Lake Erie, Long Point National Wildlife Area, Gravelly Bay, 24 km SE of Turkey Point, interdunal wet swales with *Larix laricina* and *Thuja occidentalis*, 20.vii.2021, corticolous on *L. laricina*, S.R. Brinker 8868 (CANL, hb. Brinker); Backus Woods Natural Area, 12 km W of Turkey Point, 4 km N of Port Rowan, successional woods with occasional openings in *Juglans nigra* and mixed conifer plantation, 28.ix.2022, corticolous on twig of *Picea glauca*, S.R. Brinker 9598 (CANL).

**\*\**Thelidium zwackhii* (Hepp) A. Massal.**

**FIGURE 4F.**

*Thelidium zwackhii* is a widespread pyrenocarpous lichen found throughout portions of the central and eastern United States (Brodo 2016). In the Great Lakes Basin, it has been reported from Illinois (Hyerczyk 2005), Michigan (Harris 2015), New York (Harris 2004) and Ohio (Curtis 2019). It is an early colonizer of base-rich rocks and pebbles often in humid situations where it tends to be short-lived (Orange 2013). In the study area, it was found on limestone pebbles on exposed soil at the base of a large, upturned tree in a mature forest, and a shelving limestone outcrop in a coniferous forest along a river. A query of CNALH revealed one unpublished collection made by Irwin Brodo in 1997 from Ottawa (*Brodo 29223*, NY) though it was not included for the region by Brodo et al. (2021). Therefore, the species is reported here for the first time from Canada.

*Thelidium zwackhii* can be recognized by its small, superficial perithecia (0.1–0.3 mm in diameter) that lack an involucrellum and do not form pits in the rock surface, and its four-celled ascospores (Orange 2013). Several additional species of *Thelidium* occur in Ontario that could be confused with this species. *Thelidium papulare* (Fr.) Arnold also has superficial perithecia but can be distinguished by the presence of a well-developed involucrellum and larger perithecia (0.4–0.8 mm; Brodo 2016). *Thelidium minutulum* Körb. also has superficial perithecia but can be differentiated from *T. zwackhii* by its two-celled ascospores (Brodo 2016). Both *T. fontigenum* A. Massal. and *T. decipiens* (Nyl.) Krempelh. are different from *T. zwackhii* macroscopically in having immersed perithecia that form distinct pits on the rock surface (Orange 2013). *Thelidium decipiens* has two-celled ascospores and *T. fontigenum* has four-celled ascospores (Brodo 2016, Orange 2013).

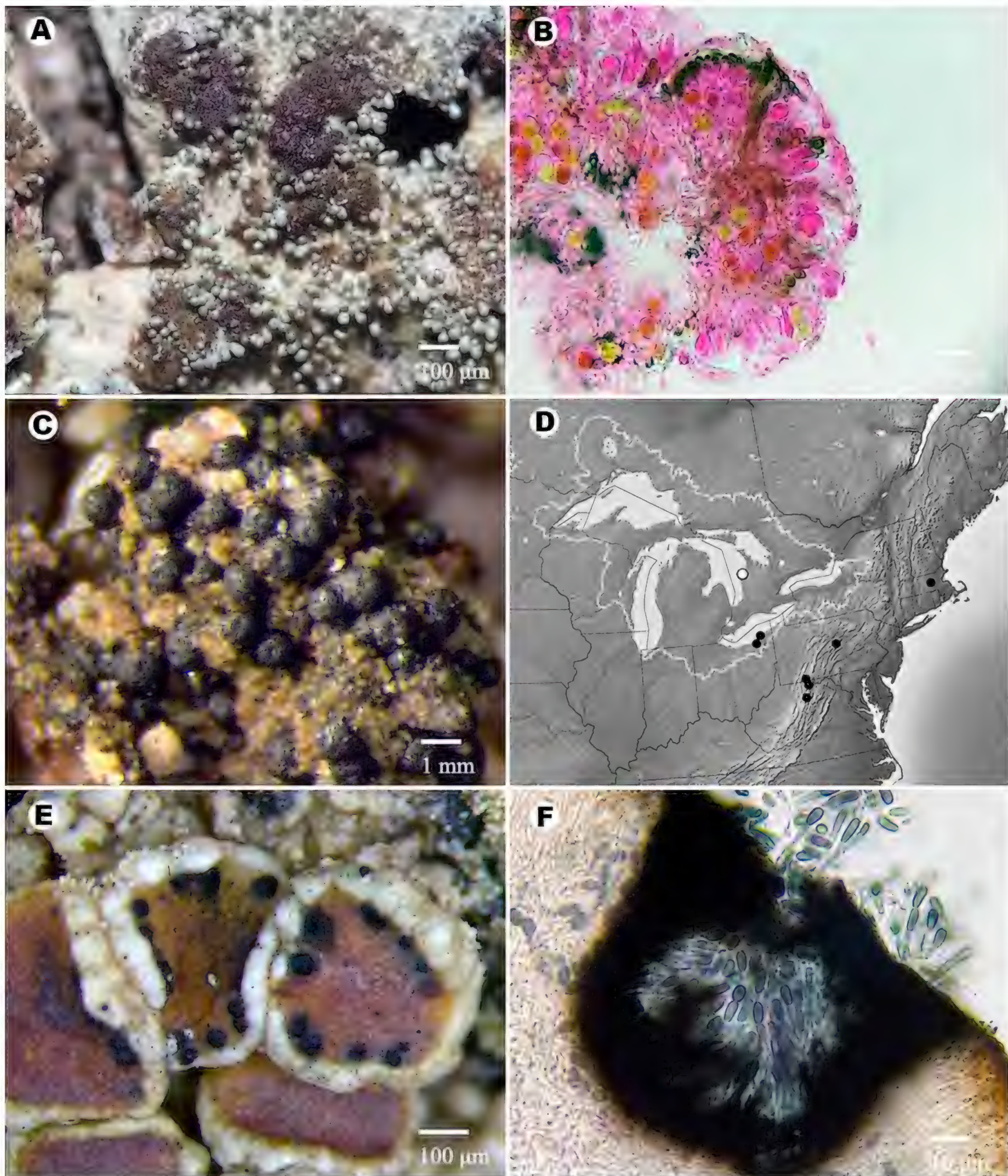
*Specimens examined.* – **CANADA. ONTARIO.** HASTINGS CO.: Callaghan's Rapids Conservation Area, Crowe River, 4 km S of Marmora, shelving limestone outcrop with scattered *Juniperus communis*, 19.x.2021, saxicolous on limestone fragment, S.R. Brinker 9160 (CANL). PETERBOROUGH CO.: Mark S. Burnham Provincial Park, E side of Peterborough, mature forest with *Tsuga canadensis* and *Acer saccharum*, 4.v.2021, saxicolous on limestone pebbles, S.R. Brinker 8746 with C. Cooke (hb. Brinker).

**\*\**Tremella imshaugiae* Diederich, Coppins, R. C. Harris, Millanes & Wedin**

**FIGURES 5A & 5B.**

This recently described taxon is so far known from only two collections, including the type that was collected in Scotland (Diederich et al. 2020). It forms convex, gelatinous, amber-coloured basidiomata





**Figure 5.** Photographs and distribution map of lichens and allied fungi new to Canada (white = newly reported Ontario records, black = previous collections). **A**, *Tremella imshaugiae* with small amber coloured basidiomata on *Imshaugia aleurites* (Brinker 9178). **B**, *T. imshaugiae* in Phloxine with basidia (Brinker 9178). **C**, *Verrucaria bryoctona* (Brinker 9096). **D**, distribution of *V. bryoctona* in eastern North America. **E**, *Vouauxiella lichenicola* on apothecia of *Lecanora* (Brinker 5271). **F**, section through *V. lichenicola* pycnidia (Brinker 5271).



on the thallus of *Imshaugia aleurites* (Ach.) S. F. Meyer (Diederich et al. 2020). The distribution is still unclear, with only one other North American collection from Maine. The collection reported here is the first from Canada and the Great Lakes Basin.

*Tremella imshaugiae* is characterized by having two to four-celled, mainly longitudinally septate basidia averaging  $15.5\text{--}21.5 \times 13\text{--}16.5 \mu\text{m}$ , and relatively large, subspherical basidiospores measuring  $6.5\text{--}9 \times 6.5\text{--}8.5 \mu\text{m}$  (Diederich et al. 2020). It is the only non-gall forming species of *Tremella* restricted to *I. aleurites* to be expected in Ontario and therefore is not likely to be confused with other lichenicolous species of *Tremella*, all of which occur on other hosts (i.e., *T. candelariellae* Diederich & Etayo, *T. everniae* Diederich, *T. cetrariicola* Diederich & Coppins and *T. hypogymniae* Diederich & M. S. Christ).

*Specimen examined.* – **CANADA. ONTARIO.** PARRY SOUND DIST.: 16 km W of Algonquin Park, 6 km E of Lake Bernard, small *Larix laricina* and *Picea mariana* treed peatland surrounded by upland mixed forest, 20.x.2021, lichenicolous on *Imshaugia aleurites* on conifer twigs, S.R. Brinker 9178 (CANL; conf. P. Diederich, from photographs).

**\*\**Verrucaria bryoctona* (Th. Fr.) Orange**

**FIGURES 5C & 5D.**

*Verrucaria bryoctona* is an inconspicuous pioneer of base-rich soil, often growing among and over bryophytes in open habitats such as dunes or other disturbance-maintained or transient habitats (Orange 1991). It is widespread in Europe and has been reported from North America from West Virginia by Breuss (2002). During the present study it was collected from a sheltered, stable sand dune adjacent to Lake Huron. This is the first report from Canada and the first terricolous *Verrucaria* species confirmed to occur in Ontario.

The species can be identified by its terricolous habit, thallus which is composed of tiny, unpigmented grey-green goniocysts, semi-immersed black perithecia 0.1–0.3 mm wide and lacking an involucrellum (Fig. 5C), and simple or rarely up to four-celled (when overmature), ellipsoid ascospores  $19\text{--}26 \times 6\text{--}7 \mu\text{m}$  frequently with small gelatinous appendages (Orange 1991, Orange et al. 2009).

*Specimen examined.* – **CANADA. ONTARIO.** BRUCE CO.: Inverhuron Provincial Park, E shore of Lake Huron, 5 km S of Baie Du Doré, open sand dune with scattered *Pinus sylvestris*, *Juniperus communis* and *Sporobolus rigidus* var. *magnus*, 16.ix.2021, among sparse bryophyte cover over calcareous sand, S.R. Brinker 9096 (CANL).

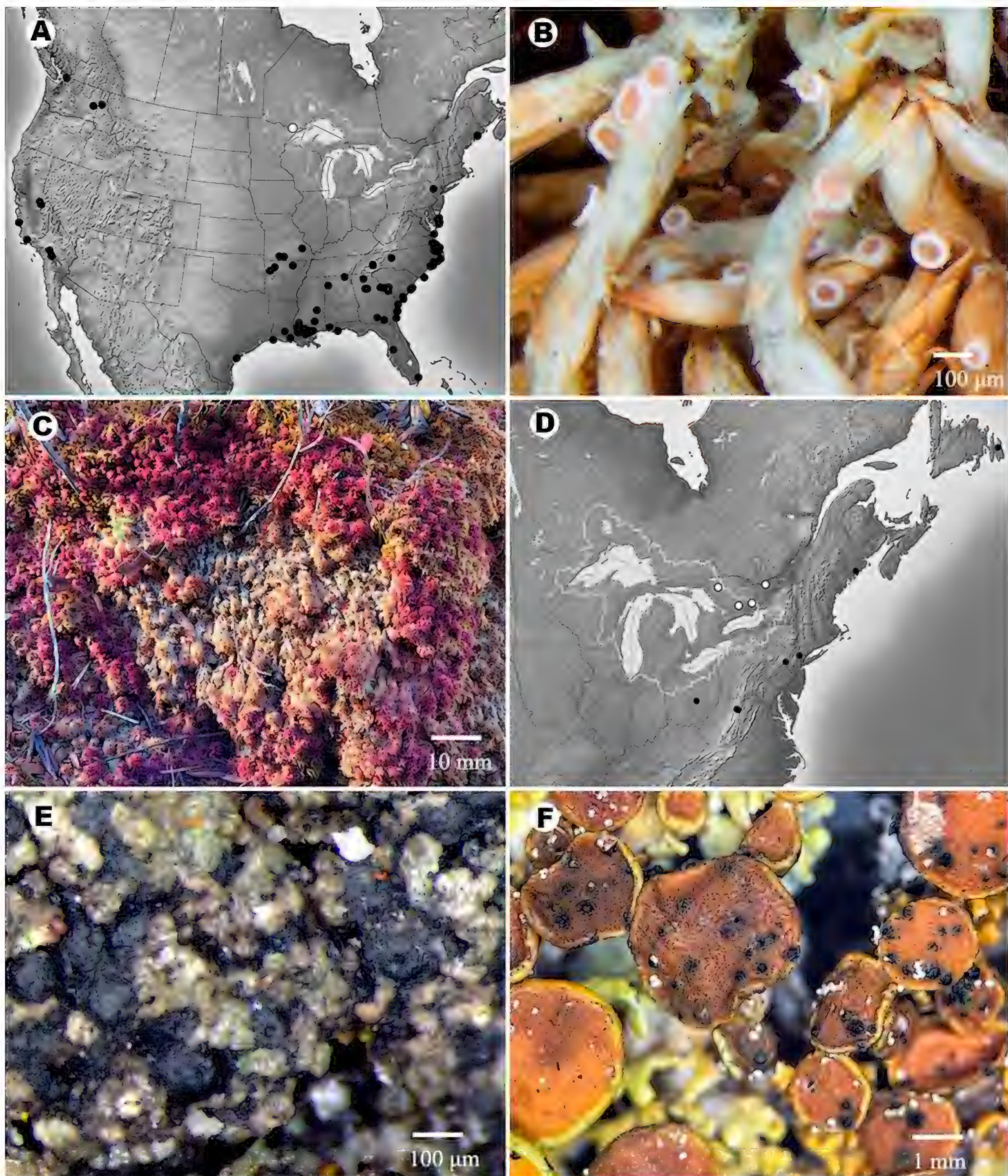
**\*\**Vezdaea schuyleriana* Lendemer**

*Vezdaea schuyleriana* was described from Pennsylvania, U.S.A by Lendemer (2011b). It has since been reported from Ohio (Curtis 2019), and a search of CNALH (accessed 03, December 2021) revealed additional collections from Kansas and New Jersey. Favoured habitats for members of the genus tend to be shaded rock walls and logs, as well as heavy-metal contaminated soils and other substrates including plant debris, moribund bryophytes and lichens (Coppins 1981, Gilbert 1980). *Vezdaea* species are ephemeral, with suitably mature material best obtained during cool, wet months when ascocarps develop (Gilbert 1980). Therefore, surveys should be timed appropriately to not overlook members of the genus. The collection reported here was made from disturbed soil at the edge of mixed woods under an electric power transmission corridor. The apothecia were visible as small gelatinous pale dots when fresh but are hardly discernable in the dry material.

*Vezdaea schuyleriana* can be identified by its sessile apothecia, eight-spored asci with abundant loose paraphyses not entwining individual asci, and simple ascospores  $14\text{--}18 \times 8.4\text{--}11 \mu\text{m}$  (Lendemer 2011b). Two other *Vezdaea* species have been reported from Ontario: *V. leprosa* (P. James) Vězda and *V. acicularis* Coppins (Brodo 2001, Brodo et al. 2013). *Vezdaea leprosa* differs from *V. schuyleriana* in having stipitate rather than sessile apothecia and narrower ascospores ( $2.5\text{--}4 \mu\text{m}$  wide; Lendemer 2011b). *Vezdaea acicularis* is readily differentiated by its acicular eight to 12-celled ascospores measuring  $60\text{--}85 \times 2\text{--}2.5 \mu\text{m}$  (Coppins 1981). Members of this genus are extremely inconspicuous and easily overlooked, so more records and species should be expected.

*Specimen examined.* – **CANADA. ONTARIO.** CITY OF OTTAWA: 13 km S of Ottawa River, 10 km SSW of Orleans, along cleared electric transmission corridor through mixed woods, 8.ix.2021, terricolous on soil at edge of mixed woods, S.R. Brinker 9139 (CANL).





**Figure 6.** Photographs and distribution maps of lichens and allied fungi new to Ontario (white = newly reported Ontario records, black = previous collections). **A**, distribution of *Vouauxiella lichenicola* in North America. **B**, *Absconditella sphagnum* on *Sphagnum fuscum* (Brinker 9197). **C**, *Sphagnum fuscum* colonized by *A. sphagnum* bleaching surface of moss cushion. **D**, distribution of *A. sphagnum* in North America. **E**, *Agonimia gelatinosa* (Brinker 8548). **F**, *Didymocyrtis xanthomendozae* on apothecia of *Xanthomendoza hasseana* (Brinker 9414).



**\*\*†*Vouauxiella lichenicola* (Lindsay) Petr. & Sydow**

**FIGURES 5E, 5F & 6A.**

*Vouauxiella lichenicola* is a lichenicolous coelomycete that is common and widespread in temperate regions of North America with reports ranging from South Carolina south to Florida and west to California (Diederich 2003). It forms pycnidia between the disc and margin of host apothecia of various members of the genus *Lecanora* Ach. (Fig. 5E). This is the first report from Canada (Fig. 6A).

This species can be recognized by its ecology, and its simple, catenate, smooth to verruculose, bluish green conidia arising in chains (Fig. 5F), measuring  $6-9 \times 3-3.5(-4) \mu\text{m}$  (Czyżewska & Kukwa 2009, Diederich 2004c). The conidia of material studied here matched well with published descriptions, ranging in size from  $6.6-8.1 \times 3.5-3.9 \mu\text{m}$ . *Vouauxiella verrucosa* (Vouaux) Petr. & Syd. is very similar with comparably sized pycnidia and conidia. However, its conidia have a coarse wart-like ornamentation (Hawksworth 1976). It has not been reported from Canada but could be easily confused with *V. lichenicola*.

*Specimen examined.* – **CANADA. ONTARIO. RAINY RIVER DIST.:** Quetico Provincial Park, 75 km SE of Atikokan, S shore of Emerald Lake near NE end, conifer woods with overstorey of *Pinus resinosa* and understorey of scattered *Thuja occidentalis*, 19.viii.2016, lichenicolous on apothecia of *Lecanora* sp. on twigs of *T. occidentalis*, S.R. Brinker 5271 with Perry Scott (CANL, hb. Brinker).

**SPECIES NEW TO ONTARIO**

The following five lichens, five lichenicolous fungi and one non-lichenized fungus were not included in the first published Ontario lichen checklist (Newmaster et al. 1998) or other more recent relevant Ontario published literature. There is a more recent list of lichens produced by Newmaster and Ragupathy (2012). However, the basis of the additional records not mentioned in Newmaster et al. (1998) are not provided or supported with any documentation. Several of the following species were listed by those authors but without supporting citations of vouchers.

**\**Absconditella sphagnum* Vězda & Poelt**

**FIGURES 6B, 6C & 6D.**

*Absconditella sphagnum* is an ephemeral lichen that occurs on *Sphagnum* (Fig. 6B) in peat bogs or more rarely on other bryophytes or lignum adjacent to its preferred habitat (Czarnota & Kukwa 2008). It produces pale, whitish or cream-coloured, concave apothecia that appear pinkish when wet, and often gives the surface of moss cushions a moribund look (Fig. 6C). It has been reported from scattered locations in eastern North America including Maine (Seaward et al. 2017), New York (Harris 2004) and Pennsylvania (Lendemer 2012). The records published here extend the range of *A. sphagnum* east to the Great Lakes Basin (Fig. 6D) where it was found on *S. fuscum* in *Chamaedaphne calyculata* dominated peatlands. This species will likely turn out to be more widespread and common with additional, suitably timed, searches of peatlands elsewhere in the region conducted during cool, wet months.

Two other species in the genus, *A. lignicola* Vězda & Pišút and *A. trivialis* (Willey ex Tuck.) Vězda have been reported from Ontario (Brinker 2020, McMullin et al. 2015). Both have four-celled ascospores and occur on either lignum (*A. lignicola*) or on mosses over heavy-metal contaminated soil or rock (*A. trivialis*) (Coppins 2009). *Absconditella sphagnum* can be readily differentiated from these two species based on its ecology and two-celled ascospores. *Coenogonium pineti* (Ach.) Lücking & Lumbsch is similar in appearance with pale apothecia growing over bryophytes, but that species differs from *A. sphagnum* in having a trentepohlioid (vs. chlorococcoid) photobiont and I- hymenium (vs. I+ blue) (McCune 2017).

*Specimens examined.* – **CANADA. ONTARIO. CITY OF OTTAWA:** Mer Bleue Bog, 7.5 km S of Orleans, *Chamaedaphne calyculata* – dominated peatland with scattered *Larix laricina*, 27.xii.2021, on *Sphagnum*, S.R. Brinker 9315 (CANL). **LENNOX & ADDINGTON CO.:** Puzzle Lake Provincial Park, 34 km N of Napanee, 5 km E of Sheffield Long Lake, *C. calyculata* – dominated peatland with scattered *Pinus strobus*, 28.iv.2022, on *Sphagnum*, S.R. Brinker 9325 (CANL). **PARRY SOUND DIST.:** Eagle Lake Bog, 6.3 km SW of South River, 4 km E of Eagle Lake, *C. calyculata* – dominated peatland with scattered *L. laricina* and *Picea mariana*, 24.x.2021, on *S. fuscum*, S.R. Brinker 9197 (CANL, hb Brinker). **PETERBOROUGH CO.:** Petroglyphs Provincial Park, 2 km N of Stony Lake, ericaceous shrub peatland with *C. calyculata*, *Rhododendron groenlandicum* and scattered *P. strobus*, 28.x.2021, on *S. fuscum*, S.R. Brinker 9201 (CANL, hb Brinker).

**\**Agonimia gelatinosa* (Ach.) Brand & Diederich**

**FIGURE 6E.**

*Agonimia gelatinosa* is a widespread arctic to boreal-montane species in North America, occurring on mosses or soil in calcareous habitats (Thomson 1997, as *Polyblastia gelatinosa* (Ach.) Th. Fr.). It occurs locally beyond that region south to the Great Lakes Basin, with reports from Michigan (Harris 2015), New York (Harris 2004) and Ohio (Curtis 2019). It was listed from Ontario by Newmaster and Ragupathy (2012), but without supporting citations. These are the first confirmed records for the province.

During the present study, *A. gelatinosa* was collected from alvars and marble barrens on shallow calcareous soil. In addition to its ecology, it can be differentiated from other members of the genus by the dark-brown granular thallus composed of small, fully-attached goniocysts, superficial, globose perithecia 0.3–0.5 mm in diameter, eight-spored asci, and muriform ascospores  $30\text{--}50 \times 15\text{--}20 \mu\text{m}$  with 15–30 cells (Breuss 2020, Hafellner 2014, Orange & Purvis 2009). It can be separated from *Polyblastia* by the two or three-layered exciple, lack of an involucrellum and consistently colourless ascospores (Orange & Purvis 2009).

*Specimens examined.* – **CANADA. ONTARIO.** BRUCE CO.: E shore of Lake Huron, Greenough Harbour, 5 km W of Stokes Bay, low shrubland alvar with *Juniperus horizontalis*, *Schizachyrium scoparium* and *Carex crawei*, 16.ix.2021, over mosses on seasonally flooded limestone pavement, S.R. Brinker 9093 (CANL). CITY OF OTTAWA: Stony Swamp off Old Richmond Rd., 3.5 km S of Bells Corners, seasonally wet sandstone flatrock intergrading into open mixed woodland with *Juniperus communis*, *Quercus rubra* and *Pinus banksiana*, 10.x.2021, over mosses on sandstone, S.R. Brinker 9145 (CANL). FRONTENAC CO.: Mountain Chute Station along Madawaska River, 18.5 km SW of Calabogie, open mixed woods with low rolling rock outcrops with *Pinus banksiana*, *Betula papyrifera* and *Populus tremuloides*, 28.viii.2020, terricolous on shallow calcareous soil, S.R. Brinker 8548 (CANL, hb. Brinker). HASTINGS CO.: 6.6 km E of Myrehall, 2.6 km SW of Mud Lake, edge of alvar grassland, 20.ix.2020, terricolous on shallow xero-hydric calcareous soil over limestone, S.R. Brinker 8696 (hb. Brinker). RENFREW CO.: Centennial Lake Provincial Park, north shore of Black Donald Lake, 23 km WSE of Calabogie, S-facing deciduous woods with *Quercus rubra* and *Ostrya virginiana*, 2.ix.2021, on mosses and detritus over shallow calcareous soil, S.R. Brinker 9036 (NY).

**\*†*Didymocyrtis xanthomendozae* (Diederich & Freebury) Diederich & Freebury**

**FIGURE 6F.**

*Didymocyrtis xanthomendozae* is a lichenicolous coelomycete on *Xanthomendoza hasseana* (Räsänen) Søchting, Kärnefelt & S.Y. Kondr. and *X. montana* (L. Lindblom) Søchting, Kärnefelt & S.Y. Kondr. (Lawrey et al. 2012, as *Phoma xanthomendozae* Diederich & Freebury). It has been reported from scattered locations in North America including Québec and Saskatchewan in Canada (Lawrey et al. 2012), as well as from California and Idaho in the United States (Haldeman 2019). These are the first reports from Ontario and the first for the Great Lakes Basin.

The species produces conidiomata, or more rarely ascomata, that are immersed in the host apothecia (rarely in the host thallus), which cause dark red to brown discolorations as infected parts of the host die (Ertz et al. 2015, Lawrey et al. 2012). The species can be separated from other members of the genus based on its host specificity; pycnidia, which are 140–160  $\mu\text{m}$  in diameter; conidiogenous cells, which line the inner wall of the pycnidial cavity and are hyaline, smooth-walled, and measure  $5\text{--}10 \times 2.5\text{--}3.5 \mu\text{m}$ ; and ellipsoid, hyaline, (1–)2-guttulate conidia, which arise singly, measuring  $(4.5\text{--})5.6\text{--}7.1\text{--}(8.6) \times (2.9\text{--})3.3\text{--}4.3\text{--}(4.6) \mu\text{m}$  (Lawrey et al. 2012, as *P. xanthomendozae*). If produced, ascospores are pale-brown and two-celled, measuring  $11\text{--}13 \times 6\text{--}7 \mu\text{m}$  (Ertz et al. 2015).

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: 9.8 km SSW of Plevna, 1.3 km N of Kashwakamak Lake, upland hardwood forest with *Acer saccharum*, *Tilia americana* and *Abies balsamea*, 30.v.2022, lichenicolous on apothecia of *Xanthomendoza hasseana* on fallen twig, S.R. Brinker 9371 & G. Cameron (hb. Brinker). LANARK CO.: Silver Lake Provincial Park, E side of Silver Lake, 26 km W of Perth, upland mixed forest with *A. saccharum*, *Tsuga canadensis*, *T. americana* and *A. balsamea*, 3.xi.2022, lichenicolous on apothecia of *X. hasseana* on *T. americana*, S.R. Brinker 9655 (CANL). LENNOX & ADDINGTON CO.: Mount Moriah Conservation Reserve, 22.5 km NNE of Madoc, rocky deciduous hardwood forest in valley with *A. saccharum*, *Ostrya virginiana* and *T. americana*, 16.vi.2022, lichenicolous on apothecia of *X. hasseana* on fallen twig, S.R. Brinker 9414 (CANL). RENFREW CO.: Westmeath Provincial Park, W of Sandpoint, 15 km SE of Pembroke, shoreline with scattered *Quercus*



*rubra*, *Fraxinus pennsylvanica* and *Q. macrocarpa*, 23.viii.2022, lichenicolous on apothecia of *X. hasseana* on twigs, S.R. Brinker 9535 (CANL).

**\*+*Distopyrenis americana* Aptroot**

**FIGURE 7A.**

*Distopyrenis americana* is a non-lichenized pyrenocarpous species that has routinely been studied by lichenologists. It has an Appalachian–Great Lakes distribution in North America (Tripp & Lendemer 2020) and these appear to be the first published reports for Ontario. A CNALH search (accessed 26, November 2021) turned up two unpublished records from the City of Ottawa made in 2011 by J. Lendemer and I. Brodo, though it was not included for the region by Brodo et al. (2021). Therefore, the species is reported here for the first time from Ontario. The species can be recognized by its ecology, restricted to the smooth bark and branches of *Betula alleghaniensis*, and its black, semi-immersed, round to slightly elongated perithecia and brown, two-celled polarilocular spores (Harris 1995).

*Specimens examined.* – **CANADA. ONTARIO.** BRANT CO.: App’s Mills Conservation Area, 8.5 km W of Brantford, lowland deciduous forest along Whitemans Creek, 31.xii.2021, corticolous on *Betula alleghaniensis*, S.R. Brinker 9316 (hb. Brinker). LENNOX & ADDINGTON CO.: Black River, 20 km N of Actinolite, lowland mixed forest with *Acer rubrum*, *Abies balsamea* and *B. alleghaniensis*, 14.v.2022, corticolous on *B. alleghaniensis*, S.R. Brinker 9395 (CANL). PETERBOROUGH CO.: Brookwood Conservation Area, 9 km N of Norwood, 8 km E of Warsaw, mixed lowland forest with *A. balsamea*, *Populus tremuloides*, *A. rubrum* and *Fraxinus nigra*, 20.vii.2020, corticolous on bark of *B. alleghaniensis*, S.R. Brinker 8490 (CANL); Otonabee Region Agreement Forest, 4 km S of Stoney Lake and E of White Lake, mixed swamp surrounded by upland woods with *Ulmus americana*, *Thuja occidentalis*, *F. nigra* and *A. balsamea*, 31.xii.2020, corticolous on *B. alleghaniensis*, S.R. Brinker 8500 (CANL); Crowe River Conservation Reserve, 15 km E of Apsley, mixed swamp in valley with *F. nigra*, *T. occidentalis* and *A. balsamea*, 29.v.2022, corticolous on *B. alleghaniensis*, S.R. Brinker 9362 (CANL).

**\*†*Lichenochora obscuroides* (Linds.) Triebel & Rambold**

**FIGURES 7B & 7C.**

*Lichenochora obscuroides* appears to be scattered but widespread in North America having previously been reported from Arizona, British Columbia, Michigan, New York, and North Carolina (Goward et al. 1994, as *L. thallina* (Cooke) Hafellner; Diederich 2003, Hafellner et al. 2002, Lendemer et al. 2013). Elsewhere it is widely distributed in Europe from Scandinavia to the Mediterranean where it can be common (von Brackel 2008). It is a gall inducing lichenicolous ascomycete occurring on members of the Physciaceae, and the host of the type specimen is *Phaeophyscia orbicularis* (Necker) Moberg (Hafellner 2019). The specimens cited here were collected on *P. pusilloides* (Zahlbr.) Essl. and *P. sciastra* (Ach.) Moberg and are the first reports from Ontario.

In addition to its host preference, this species can be recognized by its immersed perithecia measuring 180–240 µm in diameter and its hyaline, two-celled ascospores measuring 15–18 × 5–7 µm (Hawksworth et al. 2010). *Lichenochora obscuroides* is most likely to be confused with *Pyrenidium aggregatum* K. Knudsen & Kocourk. which also forms perithecia in convex galls on thalli of *Phaeophyscia*. However, that species it is most often found on *P. rubropulchra* (Degel.) Essl. and has dark-brown, four-celled ascospores (Knudsen & Kocourková 2010).

*Specimens examined.* – **CANADA. ONTARIO.** HASTINGS CO.: Beaver Creek, 11 km E of Cordova Lake, 10 km S of Marmora, along rocky section of river through upland mixed forest with *Tsuga canadensis*, *Thuja occidentalis*, *Acer saccharum* and *Betula alleghaniensis*, 19.x.2021, lichenicolous on thallus of *Phaeophyscia sciastra* on rock, S.R. Brinker 9163 (CANL, hb. Brinker). PETERBOROUGH CO.: Warsaw Caves Conservation Area 12 km E of Lakefield, 7 km S of White Lake, upland *T. occidentalis*-dominated coniferous forest with extensive shaded limestone outcrops, 7.i.2023, lichenicolous on *P. pusilloides* on *Tilia americana*, S.R. Brinker 9722 (CANL).

**\*†*Paranectria oropensis* (Ces. ex Rabenh.) D. Hawksw. & Piroz.**

**FIGURE 7D.**

North American reports of *Paranectria oropensis* are scant and widespread, from British Columbia, Massachusetts, Mexico, Minnesota, and Québec (Cole & Hawksworth 2001, Diederich 2003, Driscoll et al. 2016, Hafellner et al. 2002). Elsewhere it is known from Asia and Europe where it occurs on a wide variety of usually corticolous host lichens in diverse habitats including urban environments (Ertz

2004a, Hafellner & Obermayer 2009). The reports cited here, which are the first for Ontario, were from intact mature hardwood forests. The species is characterized by eight-spored asci and hyaline, muriform ascospores  $(22-25-32(-36) \times (9-11-14(-15) \mu\text{m})$  with five to eight transverse septa and one to two longitudinal septa, and appendages up to  $12 \mu\text{m}$  long. Mature ascospores of studied material measured  $27.2-30 \times 10.3-12.1 \mu\text{m}$ , and the infected portion of the host thalli were bleached.

*Specimens examined.* – **CANADA. ONTARIO.** HALIBURTON CO.: Oxtongue River – Ragged Falls Provincial Park, 25 km ENE of Hunstville, 1.5 km N of Oxtongue Lake, upland deciduous forest with *Acer saccharum*, *Betula alleghaniensis*, *Prunus serotina* and *Abies balsamea*, 9.i.2023, lichenicolous on *Phaeophyscia rubropulchra* on *A. saccharum*, S.R. Brinker 9727 (CANL). PARRY SOUND DIST.: Miskew Provincial Park, 11 km E of South River, 2 km W of Deer Lake, deciduous forest with *A. saccharum*, *Fraxinus nigra*, *B. alleghaniensis* and *A. balsamea*, 23.x.2021, lichenicolous on *Lecanora* sp. on *Populus tremuloides*, S.R. Brinker 9187 (CANL, hb. Brinker).

**\**Pertusaria sommerfeltii* (Flörke ex Sommerf.) Fr.**

**FIGURE 7E.**

*Pertusaria sommerfeltii* is a circumboreal species that in North America ranges through montane regions of the west from Alaska south to Colorado, the Sonoran Desert Region of Arizona and New Mexico, and in the east, occurs in portions of the Acadian Forest Region and the Great Lakes Basin (Dibben 1980). Typical substrates include various hardwoods and shrubs (Dibben 1980, Thomson 1997) although collections from the Southwest are from the conifer *Abies lasiocarpa* (Lumbsch et al. 1999). The collection reported here occurred in a mature mixed boreal forest on the bark of *Populus balsamifera*. This species was included in several unpublished Ontario lists (e.g., Newmaster & Ragupathy 2012) presumably based on a single mapped location in Thomson (1997) from Lake Superior. However, this collection was from Isle Royale in adjacent Michigan, U.S.A., as reported by Dibben (1980). Therefore, the collection reported here represents the first from Ontario.

*Pertusaria sommerfeltii* can be differentiated from other members of the genus by its occurrence on hardwoods, the thin, smooth, white or greyish thallus, numerous, dispersed, flattened or poriform ascomata with one to four black ostioles, a KOH+ red-violet epihymenium, broadly cylindrical asci with an ocular chamber that are eight-spored, ellipsoid ascospores measuring  $20-36 \times 12-24 \mu\text{m}$ , and chemically by the production of 2,7-dichlorolichexanthone, stictic acid, and constictic acid (Brodo 2016, Dibben 1980, Thomson 1997). *Megaspora verrucosa* is superficially similar to *P. sommerfeltii* though it can be distinguished by the absence of secondary metabolites, KOH- epihymenium, and its clavate or cylindrical-clavate asci (Dibben 1980, Lumbsch et al. 1999).

*Specimen examined.* – **CANADA. ONTARIO.** KENORA DIST.: W bank of Goose Creek, 7.6 km from Hudson Bay coast, 15 km E-SE of Fort Severn, mature mixed forest along small river with *Picea glauca* and *Populus balsamifera*, 24.vi.2014, corticolous on *P. balsamifera*, S.R. Brinker 36971 (hb. Brinker).

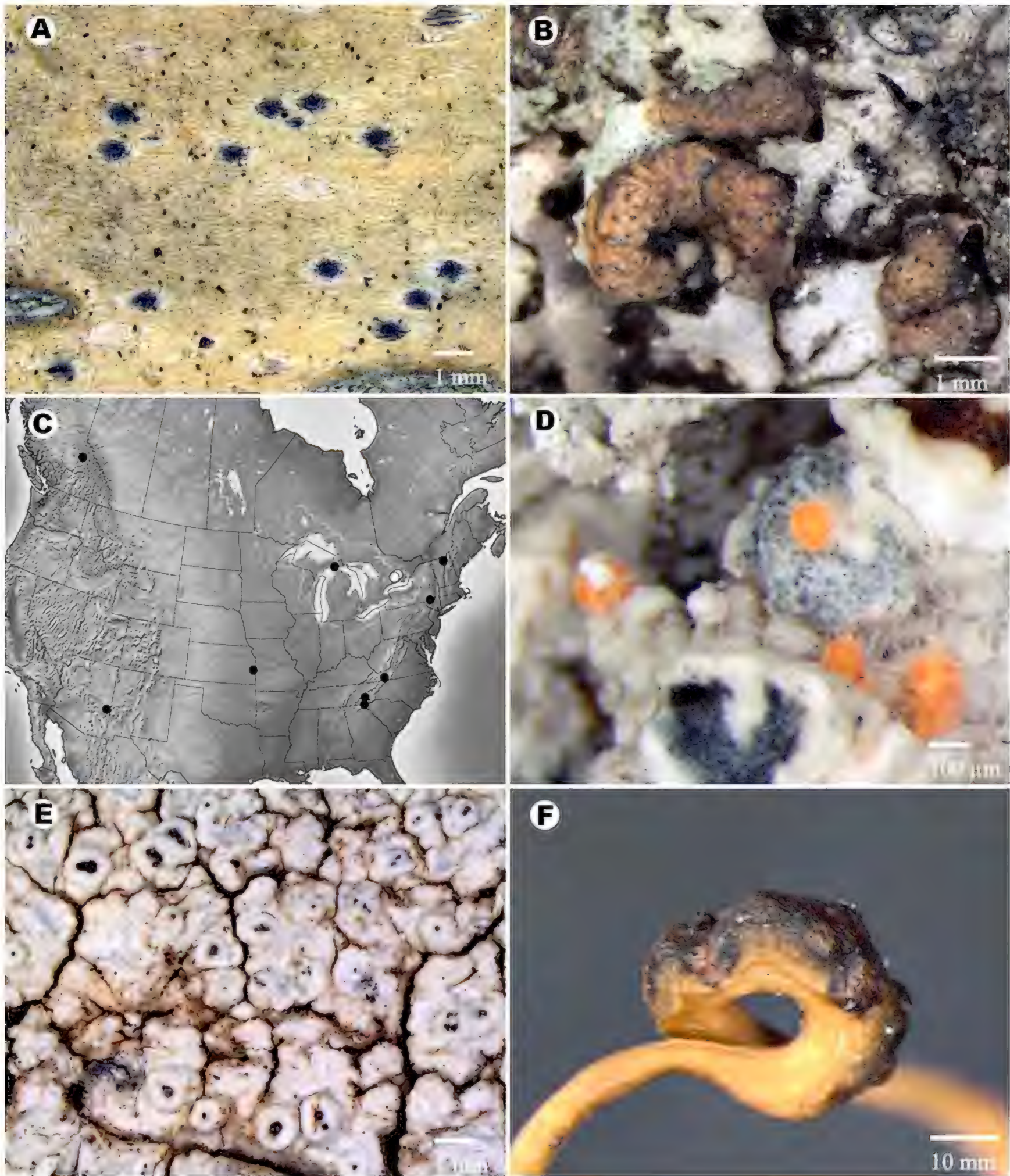
**\*†*Raesaenenia huuskonenii* (Räsänen) D. Hawksw., Boluda & H. Lindgr.**

**FIGURE 7F.**

This species has been reported mainly from montane regions of North America including Alaska, British Columbia, North Carolina, and Oregon (Goward & Ahti 1992, as *Phacopsis huuskonenii* Räsänen; Lindgren et al. 2015; Thomson & Ahti 1994, as *P. huuskonenii*; Zhurbenko & Laursen 2003, as *P. huuskonenii*). It was recently reported from the Great Lakes Basin in adjacent Minnesota, U.S.A. by Gockman et al. (2020). The specimens cited here are the first reports for Ontario. *Raesaenenia huuskonenii* is an obligate lichenicolous ascomycete on members of the genus *Bryoria* (Lindgren et al. 2015) and can be identified by its ecology, aggregated ascomata appearing as one elongated ascoma, dark brown hypothecium which is I-, and narrowly ellipsoid ascospores with thickened ends that measure  $13-17(-19) \times 3-4 \mu\text{m}$  (Triebel et al. 1995, as *P. huuskonenii*).

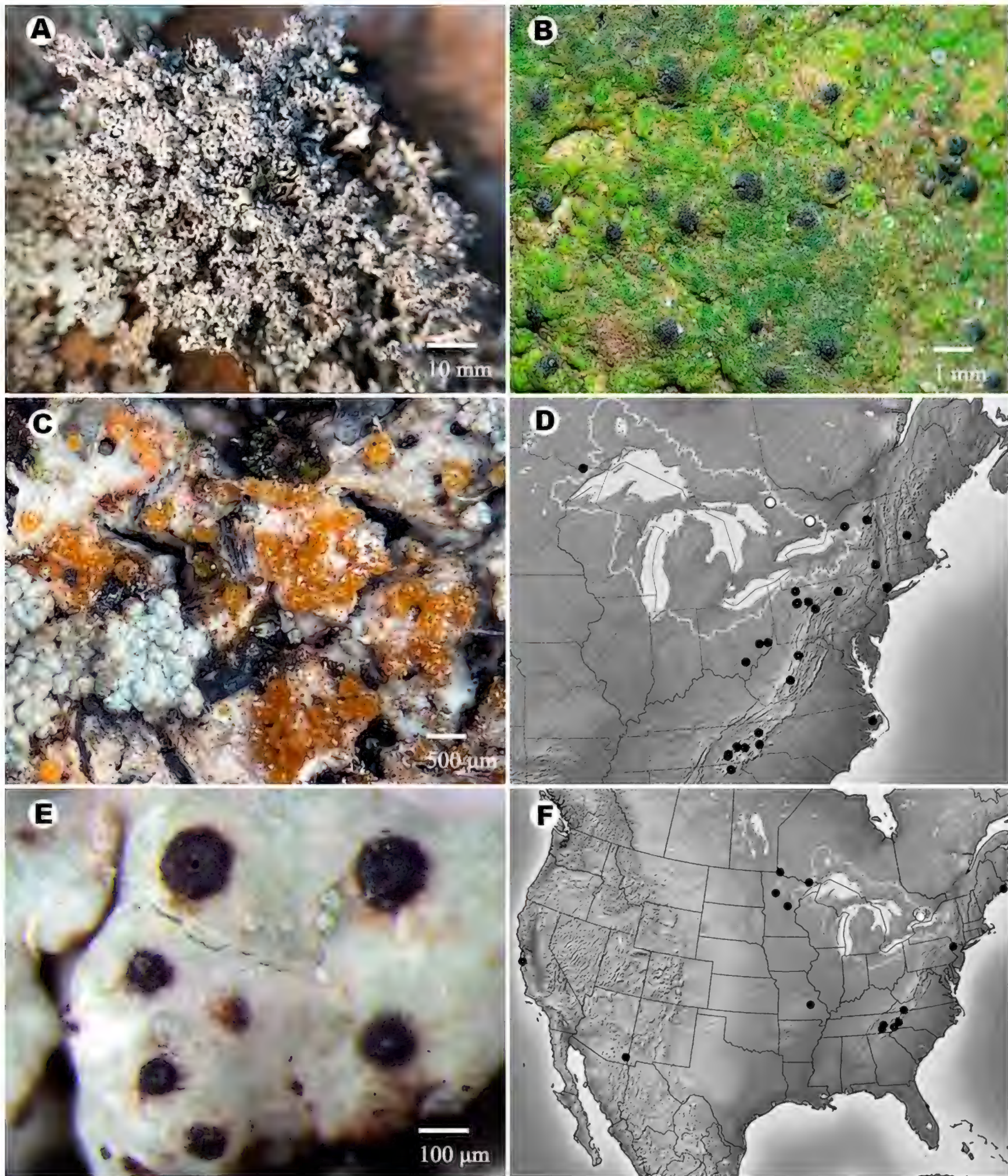
*Specimens examined.* – **CANADA. ONTARIO.** THUNDER BAY DIST.: Kama Cliffs Conservation Reserve, 9 km NNE of Kama Bay Lake Superior, 24 km NE of Nipigon, small talus slope below cliff in mixed boreal forest with *Picea mariana*, *Betula papyrifera* and *Abies balsamea*, 9.viii.2018, lichenicolous on *Bryoria fuscescens* on twigs of *P. mariana*, S.R. Brinker 7114 (hb. Brinker); Lake Superior National Marine Conservation Area, N shore of Lake Superior, interior of Lamb Island, humid coastal mixed boreal forest with *B. papyrifera*, *A. balsamea* and *Sorbus decora*, 20.vii.2019, lichenicolous on *Bryoria* sp. on bark of *B. papyrifera*, S.R. Brinker 7790 (CANL).





**Figure 7.** Photographs and distribution map of lichens and allied fungi new to Ontario (white = newly reported Ontario records, black = previous collections). **A**, *Distopyrenis americana* on bark of *Betula alleghaniensis* (Brinker 8500). **B**, *Lichenochora obscuroides* on *Phaeophyscia sciastra* (Brinker 9163). **C**, distribution of *L. obscuroides* in North America. **D**, *Paranectria oropensis* on *Lecanora* (Brinker 9187). **E**, *Pertusaria sommerfeltii* (Brinker 3697I). **F**, *Raesaenenia huuskonenii* on *Bryoria fuscescens* (Brinker 7114).





**Figure 8.** Photographs and distribution maps of lichens and allied fungi new to Ontario or otherwise rarely reported from Ontario (white = newly reported Ontario records, black = previous collections). **A**, *Stereocaulon depreaultii* (photo taken in situ, Brinker 6780). **B**, *Thrombium epigaeum* (photo taken in situ, Brinker 9162). **C**, *Trichonectria rubefaciens* on *Aspicillia* (Brinker 9189). **D**, distribution of *T. rubefaciens* in North America. **E**, *Abrothallus microspermus* on *Flavoparmelia caperata* (Brinker 8962). **F**, distribution of *A. microspermus* in North America.



**\**Stereocaulon depreaultii* Delise ex Nyl.**

**FIGURE 8A.**

*Stereocaulon depreaultii* was described from Newfoundland, and based on the few available specimens, appears to have a disjunct eastern North American and eastern Asian distribution according to Lamb (1977). It was reported by Goward et al. (1998) as rare in Canada based on collections from Newfoundland, and tentatively from Nova Scotia based on an undated specimen from the 19<sup>th</sup> century. A search of CNALH (13 December 2021) shows two additional collections from Whiteface Mountain in New York State and from Lake Superior in Minnesota, both determined by I.M. Lamb, although later she cast doubt on North American records outside of Newfoundland (Lamb 1977). It was also mentioned in a list of Ontario lichens by Newmaster and Ragupathy (2012), but no supporting specimens or documentation could be found to determine its inclusion. The specimen cited here is the first confirmed record for Ontario. Habitat descriptions include “rock surface” and “exposed granite summit” suggesting an affinity for arctic-alpine-like habitats. The material collected during this study was from exposed volcanic rock on the coast of Lake Superior and occurred with other interesting disjunct arctic-alpine species.

This species can be characterized by its suberect, 2–3 cm tall thallus that is K+ pale yellow (atranorin) and produces of lobaric acid, moderately to very dense cushions of cylindrical, caespitose pseudopodetia completely lacking tomentum, numerous phyllocladia mostly flat, grain-like, or warty to spherical or compound warty, usually 0.1–0.2 mm in diameter and mainly present in the upper parts of the pseudopodetia, and numerous sessile, spherical grey-brown botryose cephalodia (Huang & Wei 2006).

*Specimen examined.* – **CANADA. ONTARIO.** THUNDER BAY DIST.: Lake Superior National Marine Conservation Area, E shore of Macoun Island, 62 km S of Nipigon, exposed rocky coastline with splash pools and low rockfaces with *Primula mistassinica*, *Campanula rotundifolia* and *Pinguicula vulgaris*, 24.vii.2018, over volcanic rock, S.R. Brinker 6780 (OSU; det. B. McCune).

**\**Thrombium epigaeum* (Pers.) Wallr.**

**FIGURE 8B.**

*Thrombium epigaeum* is a widespread but easily overlooked ephemeral species that occurs infrequently throughout North America from New Brunswick and New England west to California, and north to Alaska and the Northwest Territories (Brodo et al. 2001, Thomson 1997). It forms a thin, continuous, grey green to greenish-brown crust with immersed perithecia over exposed, stable soils (Orange 2013; Fig. 8B). The species differs from other terricolous pyrenocarpous lichens in the region by the combination of the lack of an involucrellum, and the presence of colourless, simple ascospores and persistent paraphyses (Brodo et al. 2001, Purvis & Orange 2009). The specimen reported here was found on compacted shallow loamy soil over limestone bedrock.

*Thrombium epigaeum* has been included in various unpublished Ontario lists (e.g., Newmaster & Ragupathy 2012) presumably based on a single specimen collected in 1973 from East Pen Island (*Kershaw s.n.*, CANL 98623) bordering Ontario in Hudson Bay, but which is a part of the Territory of Nunavut. Therefore, the collection reported here represents the first collection from.

*Specimen examined.* – **CANADA. ONTARIO.** HASTINGS CO.: Callaghan’s Rapids Conservation Area, Crowe River, 3.5 km S of Marmora, mixed rocky woods with *Quercus macrocarpa*, *Juniperus communis* and *Thuja occidentalis*, 19.x.2021. terricolous on shallow soil, S.R. Brinker 9162 (CANL, hb. Brinker).

**\*†*Trichonectria rubefaciens* (Ellis & Everh.) Diederich & Schroers**

**FIGURES 8C & 8D.**

This lichenicolous ascomycete appears to have an Appalachian-Great Lakes distribution in North America with reports from North Carolina (Lendemer et al. 2016, Tripp & Lendemer 2020, as *Nectriopsis rubefaciens* (Ellis & Everh.) M.S. Cole & D. Hawksw.), Pennsylvania (Harris & Lendemer 2006, as *N. rubefaciens*), Virginia (Hodkinson et al. 2009, as *N. rubefaciens*) and a single collection from the Boundary Waters region of Minnesota (Cole & Hawksworth 2001, as *N. rubefaciens*). The collections reported here seem to be the first for the Great Lakes Basin (Fig. 8D). In eastern North America it occurs on members of the genus *Aspicilia* A. Massal. (Tripp & Lendemer 2020).

*Trichonectria rubefaciens* can be identified by its superficial, dark orange to reddish-orange perithecia, 80–160 µm in diameter with straight, colorless, thin hairs around the ostiolar region, eight-

spored asci and two-celled, ellipsoid, colourless ascospores that are  $14\text{--}18 \times 2.5\text{--}3 \mu\text{m}$  in size (Ihlen & Wedin 2008). In addition, the infected host thallus becomes necrotic in the region of the *Trichonectria* infection.

*Specimens examined.* – **CANADA. ONTARIO.** LENNOX & ADDINGTON CO.: Mount Moriah Conservation Reserve, 22.5 km NNE of Madoc, upland rocky deciduous woods with *Acer saccharum*, *Tilia americana* and *Ostrya virginiana*, 15.vi.2022, lichenicolous on *Aspicilia* sp. on granite boulder, S.R. Brinker 9398 (CANL). PARRY SOUND DIST.: Mikisew Provincial Park, 11 km E of South River, 2 km W of Deer Lake, deciduous forest with *A. saccharum*, *Fraxinus nigra*, *Betula alleghaniensis* and *Abies balsamea*, 23.x.2021, lichenicolous on *Aspicilia* sp. on granite boulder, S.R. Brinker 9189 (CANL, hb. Brinker).

#### ADDITIONAL INTERESTING OR SIGNIFICANT RECORDS

This section includes nine lichens and nine lichenicolous fungi that are included in the first published Ontario lichen checklist (Newmaster et al. 1998) or appear in more recent published literature but have rarely been reported from the province or are known from historic records.

##### †*Abrothallus microspermus* Tul.

##### FIGURES 8E & 8F.

This lichenicolous ascomycete is often reported from *Flavoparmelia caperata* (L.) Hale and other parmelioid genera including *Flavopunctelia* (Krog) Hale and *Punctelia* Krog (Lendemer 2008, Hawksworth et al. 2010, Triebel et al. 1991). In North America, it has been reported from Arizona (Triebel et al. 1991, as *Vouauxiomyces truncatus* (B.de Lesd.) Dyko & D.Hawksw.), California (Diederich 2003), Maine (Diederich 2003), Minnesota (Cole & Hawksworth 2001), North Carolina (Lendemer 2008, as *V. truncatus*) Pennsylvania (Harris & Lendemer 2006, as *V. truncatus*), Tennessee (Lendemer et al. 2013) and Virginia (Diederich 2003). It was previously known from a single Ontario collection from the Lake of the Woods region in the northwestern part of the province (Lewis & Brinker 2017). The additional records reported here add to our understanding of its distribution in the province.

*Abrothallus microspermus* can be distinguished by its host preference and brownish ascospores ranging in size from  $(9\text{--})11\text{--}13.5\text{--}(14) \times (3\text{--})4.5\text{--}5.5\text{--}6 \mu\text{m}$  (Hawksworth et al. 2010). The collections reported here represent the anamorphic stage, lichenicolous on *F. caperata*, and appear to be first for the Great Lakes Basin (Fig. 8F). The anamorph can be identified based on its host preference and hyaline, unbranched, simple conidia that measure  $6.5\text{--}7.5\text{--}(8) \times 4\text{--}5\text{--}(5.5) \mu\text{m}$  (Hawksworth et al. 2010). The name of the asexual (conidia producing) anamorph *Vouauxiomyces truncatus* has been synonymized with *A. microspermus*.

*Specimens examined.* – **CANADA. ONTARIO.** HASTINGS CO.: 13.5 km N of Marmora, 2.5 km SE of Thomson Lake, NCC Beaver Creek area of interest, deciduous swamp with *Acer xfreemanii* and *Fraxinus* spp., 16.viii.2021, lichenicolous on *Flavoparmelia caperata* on bark of *F. pennsylvanica*, S.R. Brinker 8962 & C. Terwissen (CANL). NORTHUMBERLAND CO.: Crowe River Bridge Conservation Area, 13 km SW of Madoc, open mixed woods with limestone outcrops along river with *Juniperus virginiana*, *Thuja occidentalis*, and *Quercus macrocarpa*, 9.ix.2020, lichenicolous on *F. caperata* on *J. virginiana*, S.R. Brinker 8366 (hb. Brinker). PETERBOROUGH: Warsaw Caves Conservation Area 12 km E of Lakefield, 7 km S of White Lake, upland *T. occidentalis*-dominated coniferous forest with extensive shaded limestone outcrops, 7.i.2023, lichenicolous on *F. caperata* on branch of *T. occidentalis*, S.R. Brinker 9723 (hb. Brinker).

##### *Ahtiana aurescens* (Tuck.) Thell & Randlane

*Ahtiana aurescens* is an enigmatic foliose lichen of mature, humid coniferous forests that is endemic to eastern North America (Thell et al. 1995, Wetmore 2002, as *Cetraria aurescens* Tuck.). It has declined throughout much of its range, which extends from the Boundary Waters Wilderness of Ontario and Minnesota east through the Upper Great Lakes Basin to New Brunswick and Nova Scotia, and as well as high elevation forests of the southern Appalachians (Thell et al. 1995, Tripp & Lendemer 2020). The species was recently reported from southern boreal forests of the Lake Superior and Lake of the Woods region by Brinker (2020), which still appear to be relative strongholds for the species in Canada. Elsewhere



in Ontario, it was previously known only from several historical records in the Nipissing District (Thell et al. 1995). The collections cited here are noteworthy, being made from undisturbed, mature conifer swamp habitat and are the first and only modern records from southern Ontario (Wong & Brodo 1992).

*Specimens examined.* – **CANADA. ONTARIO.** HASTINGS CO.: Conroys Marsh Conservation Reserve, 10 km S of Combermere, conifer swamp with *Thuja occidentalis*, *Abies balsamea* and *Picea glauca*, 22.vii.2022, corticolous on twig of *T. occidentalis*, S.R. Brinker 9445 (CANL). FRONTENAC CO.: Shawenegog Lake area, 10 km E of Upper Mazinaw Lake, 8 km SW of Plevna, open conifer swamp with *T. occidentalis*, *A. balsamea* and *Betula alleghaniensis*, 14.viii.2021, corticolous on twig of *A. balsamea*, S.R. Brinker 8862 (CANL).

†*Athelia arachnoidea* (Berk.) Jülich

FIGURE 9A.

*Athelia arachnoidea* is a lichenicolous basidiomycete that forms extensive cobweb-like networks of white hyphae and brown sclerotia up to one millimeter in diameter, creating large circular necrotic zones on a wide variety of crustose and foliose lichens (Motiejūnaitė & Jucevičienė 2005). Basidia are rarely produced and contain two to four basidiospores measuring  $5\text{--}9\text{--}(12) \times 2.5\text{--}7 \mu\text{m}$  (Diederich 2004a, Hawksworth et al. 2010). In Europe, this species is considered a common pathogen of epiphytic lichens, playing an important role in regulating lichen population size and community dynamics by creating gaps in otherwise closed corticolous lichen communities and clearing new patches for colonization (Motiejūnaitė & Jucevičienė 2005). There are several reports from scattered locations in North America including Arizona, Massachusetts, Pennsylvania, and Washington (Diederich 2003, Jülich 1972). Three Ontario collections were reported by Jülich (1972) including two from Simcoe County made in 1956 and one from York County made in 1950. The specimen examined for this study lacked basidiomata but was conspicuously covered with brown sclerotia and was parasitizing *Physcia millegrana* Degel.

*Specimen examined.* – **CANADA. ONTARIO.** PETERBOROUGH CO.: Squirrel Creek Conservation Area S of Wallace Point Rd. along Otonabee River, deciduous floodplain forest with *Acer ×freemanii*, *Fraxinus pennsylvanica* and *Ulmus americana*, 28.ii.2019, lichenicolous on *Physcia millegrana* on *A. ×freemanii*, S.R. Brinker 7394 (hb. Brinker).

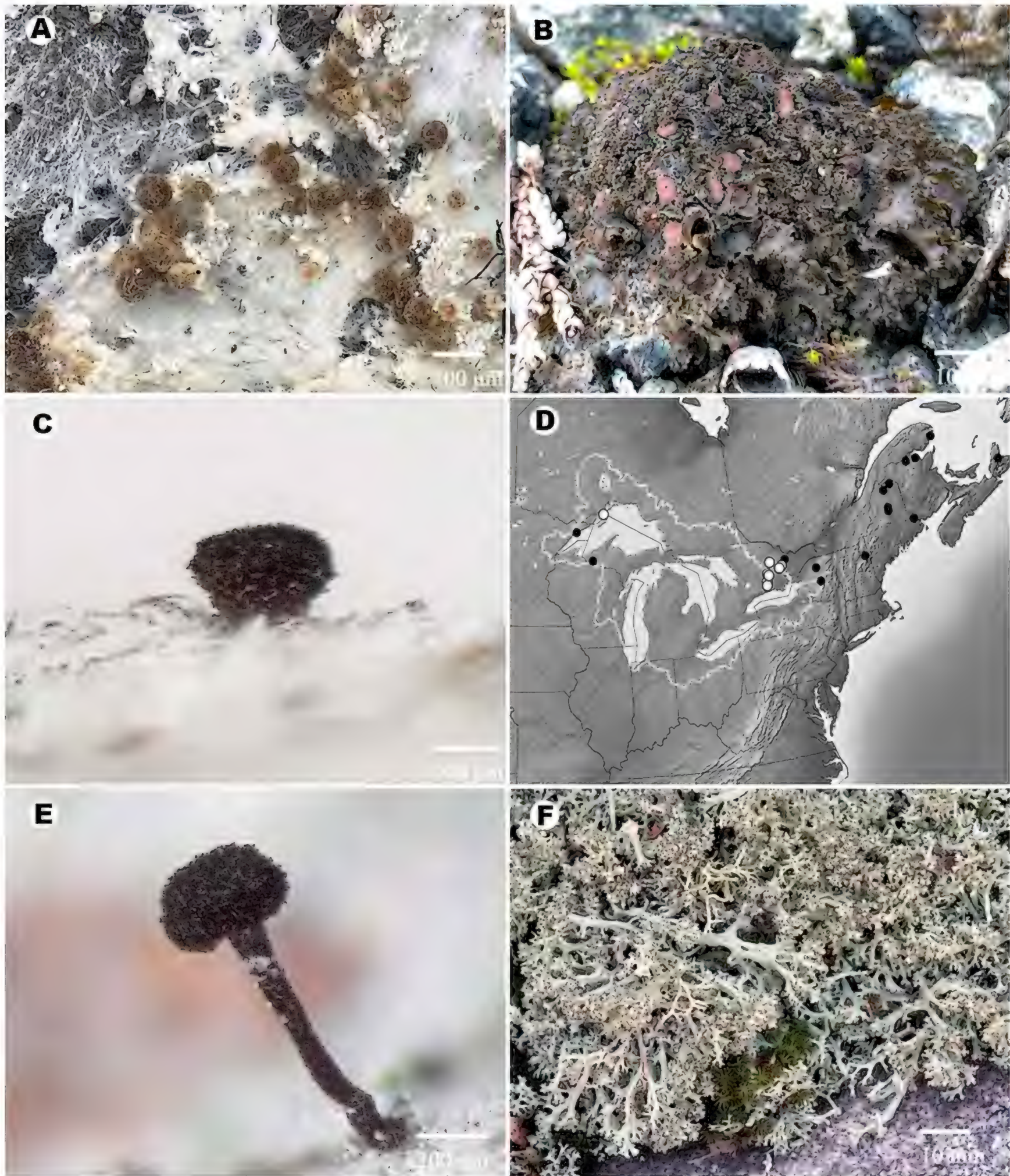
*Blennothallia crispa* (Hudson) Otálora, P. M. Jørg. And Wedin

FIGURE 9B.

*Blennothallia* Trevis. is a small, primarily temperate genus comprised of four species found to be distinct from *Collema* s.str. in a molecular phylogenetic study of Collemataceae (Otálora et al. 2014). The genus is characterized by the partially paraplectenchymatous thallus anatomy, corresponding to the *C. crispum*-group which was distinguished by Degelius (1954). *Blennothallia crispa* occurs on moist calcareous soil and rock and has a very widespread North American distribution where it is apparently most common in the West (Brodo et al. 2001, as *C. crispum* (Hudson) Weber ex F.H. Wigg.), with scattered occurrences in the Arctic and Great Lakes Basin (Thomson 1984, as *C. crispum*). The collections cited below are the first modern records from Ontario and were found in open areas with seasonally wet limestone pavement often supporting remnant alvar vegetation, and in one other instance from marble flatrock.

*Blennothallia crispa* can be identified by its numerous, rounded or ear-like, overlapping, flat to concave lobes with scale-like isidia that can resemble smaller lobes (Fig. 9B), sessile apothecia often with a constricted base, and four-celled to rarely submuriform ascospores that are  $(17\text{--})26\text{--}34\text{--}(47) \times (8.5\text{--})13\text{--}15\text{--}(18) \mu\text{m}$  in size (Cannon et al. 2020a, Degelius 1954, Schultz et al. 2004, as *C. crispum*). It is differentiated from members of *Leptogium* and *Scytinium* by its more olivaceous to black thallus and absence of a true cortex, whereas the thallus of *Leptogium* and *Scytinium* (Ach.) Gray species are more typically deep-reddish brown to slate grey and possess a proper cortex (Cannon et al. 2020a). Foliose members of *Lempholemma* Körber found in Ontario (i.e., *L. polyanthes* (Bernh.) Malme and *L. chalazanum* (Ach.) B. de Lesd.) have a similar anatomy and share the same *Nostoc* photobiont as *B. crispa*, but they have immersed ascomata and simple ascospores (Schultz et al. 2004).





**Figure 9.** Photographs and distribution map of lichens and allied fungi rarely reported from Ontario. **A**, *Athelia arachnoidea* on *Physcia millegrana* (Brinker 7394). **B**, *Blennothallia crispa* (photo taken in situ, Brinker 8719). **C**, *Chaenothecopsis brevipes* (Brinker 9014). **D**, distribution of *C. brevipes* in North America (white = newly reported Ontario records, black = previous collections). **E**, *Chaenothecopsis rubescens* Brinker (8563A). **F**, *Cladonia dimorphoclada*, (photo taken in situ Brinker 9334).



*Specimens examined.* – **CANADA. ONTARIO.** HASTINGS CO.: 8.7 km SE of Tweed, 7 km N of Naphan, treed alvar with scattered *Quercus macrocarpa*, *Juniperus virginiana* and *J. communis*, 20.xi.2020, over shallow calcareous soil over limestone pavement, S.R. Brinker 8691 (CANL, hb. Brinker); 2.5 km E of Mount Zion, 1.5 km W of Trent River, edge of abandoned limestone quarry and young *J. virginiana* coniferous woods, 17.xii.2020, over limestone, S.R. Brinker 8719 (CANL, hb. Brinker). LENNOX & ADDINGTON CO.: 7 km NE of Tamworth, 1 km E of Murphy Lake, exposed marble flatrock with scattered *J. communis* and *Quercus macrocarpa*, 28.iv.2022, over marble flatrock, S.R. Brinker 9330 (hb. Brinker) NORTHUMBERLAND CO.: Trent River, 7.5 km N of Campbellford, open limestone pavement of former river channel, 6.iv.2019, among bryophytes over limestone pavement, S.R. Brinker 7427 (CANL). PRINCE EDWARD CO.: S side of Army Reserve Rd. just W of Charwell Point Rd, scrubby *J. virginiana* alvar woodland, 9.v.2013, over seasonally wet fractured limestone bedrock, S.R. Brinker 2843B (CANL; det. F. Anderson).

†*Chaenothecopsis brevipes* Tibell

FIGURES 9C & 9D.

*Chaenothecopsis brevipes* has an Appalachian-Great Lakes distribution in North America having been reported from Maine, Minnesota, New Brunswick, New Hampshire, New York, North Carolina, Nova Scotia, Québec, and Vermont (Gockman et al. 2020; Harris 2004; Selva 1988, 2014, 2016). A single previously published record exists from Ontario from Lanark County (Selva 2010). Its range is restricted to the distribution of its host lichen, *Inoderma byssaceum* (Weigel) Gray which is an uncommon northern temperate to southern boreal species in North America (Lendemer et al. 2013, as *Arthonia byssacea* (Weigel) Almq.) that occurs on the bark of old tree trunks in locally humid, mature forests (Frisch et al. 2015). In Ontario, *I. byssaceum* has been reported to occur on *Acer saccharum*, *Betula alleghaniensis*, *Quercus macrocarpa* and *Thuja occidentalis* in mature hardwood forests (Brinker 2020, Wong & Brodo 1992). Collections of *C. brevipes* from the Great Lakes Basin have so far been restricted to host thalli found growing on *T. occidentalis*, and here that phorophyte range is expanded to include *Populus balsamifera*.

The species can be recognized by its association with *Inoderma byssaceum*, short-stalked, 0.1–0.2 mm tall, black, epruinose capitula, and two-celled ellipsoid, brown ascospores (Selva 2014). The only other short-stalked *Chaenothecopsis* species associated with lichens with a *Trentepohlia* photobiont in Ontario is *C. australis* Tibell recently reported by Brinker (2020). It can be distinguished from *C. brevipes* by its simple ascospores (Selva 2014).

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: 9 km NE of Plevna, 4.5 km W of Ompah, 800 m E of Mosque Lake, mature mixed swamp with *Thuja occidentalis*, *Fraxinus nigra* and *Abies balsamea*, 12.ix.2020, lichenicolous on *Inoderma byssaceum* on *T. occidentalis*, S.R. Brinker 8563B (CANL, hb. Brinker); Shawenegog Lake area, 10 km E of Upper Mazinaw Lake, 8 km SW of Plevna, open coniferous swamp with *T. occidentalis*, *Betula alleghaniensis*, *A. balsamea* and *Acer spicatum* surrounded by upland deciduous forest, 14.vii.2021, lichenicolous on *I. byssaceum* on *T. occidentalis*, S.R. Brinker 8861 & G. Cameron (CANL). HASTINGS CO.: 40 km S of Bancroft, 1.5 km S of Tangamong Lake, conifer swamp with *T. occidentalis*, *A. balsamea*, *Picea mariana* and *Ulmus americana*, 6.v.2019, lichenicolous on *I. byssaceum* on *T. occidentalis*, S.R. Brinker 7459B (CANL, hb. Brinker); Conroys Marsh Conservation Reserve, 10 km S of Combermere, conifer swamp with *T. occidentalis*, *A. balsamea* and *P. glauca*, 22.vii.2022, lichenicolous on *I. byssaceum* on *T. occidentalis*, S.R. Brinker 9459 (CANL). PETERBOROUGH CO.: Brookwood Conservation Area, 9 km N of Norwood, 8 km E of Warsaw, mixed lowland forest with *A. balsamea*, *Populus tremuloides*, *Acer rubrum* and *F. nigra*, 20.vii.2020, lichenicolous on *I. byssaceum* on *T. occidentalis*, S.R. Brinker 8488 (CANL, hb. Brinker); Birdsall Wildlife Area, 7.5 km E of Lang, 2 km N of Rice Lake, *T. occidentalis* conifer swamp, 8.iv.2021, lichenicolous on *I. byssaceum* on *T. occidentalis*, S.R. Brinker 8726 (hb. Brinker); 14 km S of Gooderham, 2.5 km NW of Catchacoma Lake, conifer swamp with *T. occidentalis*, *A. balsamea*, *F. nigra* and *B. alleghaniensis*, 1.ix.2021, lichenicolous on *I. byssaceum* on *P. balsamifera*, S.R. Brinker 9014 (CANL). THUNDER BAY DIST.: Sleeping Giant Provincial Park, Gardner Lake Trail area N of Otter Lake, old-growth mixed boreal forest with *T. occidentalis*, *B. papyrifera* and *P. balsamifera*, 7.ix.2019, lichenicolous on *I. byssaceum* on bark of *T. occidentalis*, S.R. Brinker 8103B (CANL).

†*Chaenothecopsis rubescens* Vain.

FIGURE 9E.

In North America *Chaenothecopsis rubescens* is mainly restricted to oceanic regions of the Acadian Forest, the Appalachian Mountains, the Ozark Highlands, and montane areas of the Northwest (Harris & Ladd 2005, Selva 2014, 2016). It occurs rarely in the Great Lakes Basin having been previously reported from Michigan (Tibell 1975). Although not explicitly reported as occurring in Ontario in the published literature, mention of *C. rubescens* was made in an unpublished report by Selva and Lee (2005) from the Snye Road northern white cedar stand in Lanark County. The collections cited here represent the first published records for Ontario and add to its known range in the province.

The species is characterized by its epruinose apothecia that are K+ red, its simple, brown ascospores measuring  $5.5\text{--}9 \times 2.5\text{--}3.5 \mu\text{m}$ , and the association with *Trentepohlia*, or *Trentepohlia*-associated lichens, namely *Inoderma byssaceum* (Selva 2014). The specimens cited here were lichenicolous on *I. byssaceum* on *Thuja occidentalis* in mature conifer swamp habitat.

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: 9 km NE of Plevna, 4.5 km W of Ompah, 800 metres E of Mosque Lake, mature mixed swamp with *Thuja occidentalis*, *Fraxinus nigra* and *Abies balsamea*, 12.ix.2020, lichenicolous on *Inoderma byssaceum* on *T. occidentalis*, S.R. Brinker 8563A (CANL, hb. Brinker). HASTINGS CO.: Conroys Marsh Conservation Reserve, 10 km S of Combermere, conifer swamp with *T. occidentalis*, *A. balsamea* and *P. glauca*, 22.vii.2022, lichenicolous on *I. byssaceum* on *T. occidentalis*, S.R. Brinker 9469 (hb. Brinker).

*Cladonia dimorphoclada* Robbins

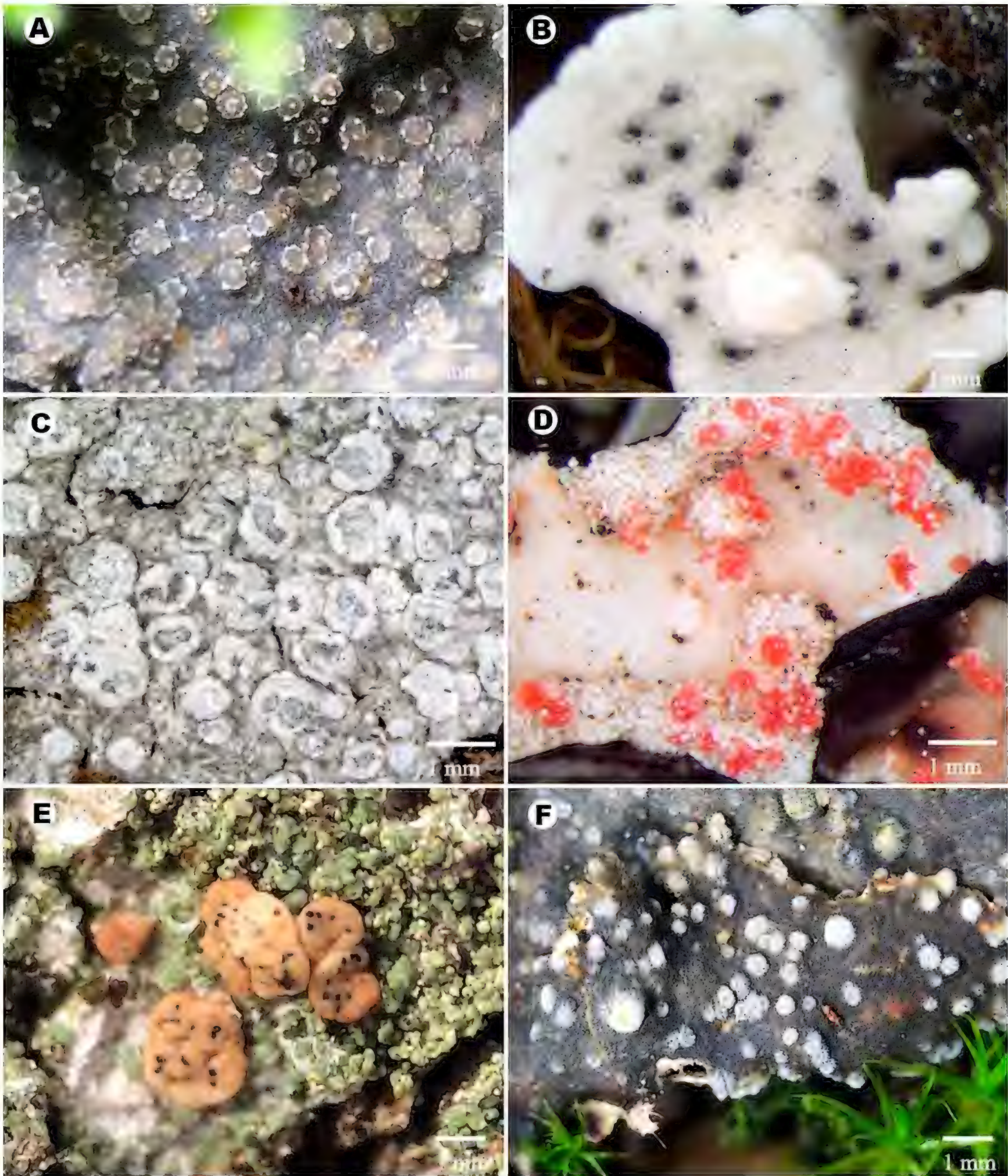
FIGURE 9F.

*Cladonia dimorphoclada* is widely distributed in eastern North America from Maine south to Florida and west to Wisconsin, Missouri and Arkansas (Ahti 1973). Throughout the region it occurs on exposed or partly shaded acidic sandy soil (Brodo et al. 2001). Previous reports of the species from Ontario are from Frontenac County (Wong & Brodo 1973, as *C. caroliniana* Tuck.) and the Melon Lake area of Lennox and Addington County (Wong & Brodo 1990). The records reported here extend its range northward to the Lake Huron Basin where the species appears to be rare and restricted to southern portions of exposed Precambrian granitic outcrops.

The cushion-forming tendency of the species with its prostrate, yellow-green (usnic acid) irregularly-branched, corticate podetia make it recognizable in the field along with its chemistry (KC+ yellow, UV-) (Lendemer & Noell 2018). The inner podetial walls (stereome) are composed of long cartilaginous strands or cords (Hinds & Hinds 2007). In the study area, the only other species of *Cladonia* likely to be confused with *C. dimorphoclada* is *C. uncialis* (L.) F. H. Wigg. *Cladonia uncialis* differs in having erect, more richly branched and inflated podetia that have abundant white maculae near the tips, inner podetial walls that are solid and smooth and sometimes pruinose, and in its chemistry, often producing squamatic acid (UV+ blue-white) in addition to usnic acid (Brodo et al. 2001, Lendemer & Noell 2018).

*Specimens examined.* – **CANADA. ONTARIO.** LENNOX & ADDINGTON CO.: Puzzle Lake Provincial Park, N shore of Puzzle Lake, 500 metres E of Gull Lake, open granitic rock outcrop above shoreline bordering edge of upland mixed rocky woods with *Pinus strobus* and *Quercus alba*, 10.x.2019, on shallow soil over bedrock, S.R. Brinker 8267 & H. Pacheco (CANL); Sheffield Conservation Area E of Mellon Lake, 9.5 km S of Kaladar, S-facing granitic outcrop with scattered *Juniperus communis*, *Q. rubra* and *Deschampsia flexuosa*, 5.v.2022, terricolous over bare granitic bedrock, S.R. Brinker 9334 (NY, hb. Brinker; conf. J.C. Lendemer). MUSKOKA DIST.: Six Mile Channel along White Falls Rd. W of Big Chute, granite barren with *P. strobus*, *Q. rubra* and *J. communis*, 19.x.2019, terricolous on bare granitic ridge, S.R. Brinker 8285 (CANL). PETERBOROUGH CO.: 24 km N of Havelock, 2 km E of Connor Bay, Kashabog Lake, extensive granitic outcrop with scattered *P. strobus* and *Q. rubra*, 6.v.2022, S.R. Brinker 9337 (hb. Brinker).





**Figure 10.** Photographs of lichens and allied fungi rarely reported from Ontario. **A**, *Corticifraga fuckelii* on *Peltigera* (photo taken in situ, Brinker 8863). **B**, *Didymocyrtis cladoniicola* on *Cladonia* squamules (Brinker 9231B). **C**, *Lepra panyrga* (Brinker 3564). **D**, *Marchandiomyces corallinus* on *Parmelia* (Brinker 9176). **E**, *Muellerella hospitans* on *Bacidia rubella* (photo taken in situ, Brinker 7392A). **F**, *Refractohilum peltigerae* on *Peltigera* (photo taken in situ, Brinker 8564).



†*Corticifraga fuckelii* (Rehm) D. Hawksw. & R. Sant.

FIGURE 10A.

There are few North America reports of this species, suggesting it is either rare or overlooked, and they are mainly from cool-temperate and montane regions. Reports exist from Alberta (Goffinet 1994), British Columbia (Goward & Ahti 1992, Noble et al. 1987, as *Phragmonevia fuckelii* Rhem), Nunavut (Alstrup 2004), and a single record has been published from Mexico (Ertz 2004b). A CNALH search (accessed 01, December 2020) revealed several additional specimens from Québec, Pennsylvania, and Vermont. In Ontario, this species was known only from a single historical collection made in Simcoe County in 1953 (Hawksworth & Santesson 1990). The collections reported here are the first modern records from the Great Lakes Basin. *Corticifraga fuckelii* can be identified by its restriction to host thalli of *Peltigera*, nearly colourless to pale to brown, immersed, immarginate ascomata that are 0.2–0.5 mm in diameter, interascal filaments with a colourless end cell, a K/I– hymenium and asci, and two-celled, smooth ascospores, that measure 12–16 × 4–6 µm (Hawksworth 1980, as *P. fuckelii*; Ilhen & Wedin 2008).

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: Shawenagog Lake area, 10 km E of Upper Mazinaw Lake, 8 km SW of Plevna, open coniferous swamp with *Thuja occidentalis*, *Betula alleghaniensis*, *Abies balsamea* and *Acer spicatum* surrounded by upland deciduous forest, 14.vii.2021, lichenicolous on thallus of *Peltigera evansiana* on mossy log, S.R. Brinker 8863 & G. Cameron (hb. Brinker). LENNOX & ADDINGTON CO.: Mount Moriah Conservation Reserve, 22.5 km NNE of Madoc, upland rocky deciduous forest with *Acer saccharum*, *Tilia americana* and *Ostrya virginiana*, 14.vii.2022, lichenicolous on *P. evansiana* on mossy rock outcrop, S.R. Brinker 9397 (CANL).

†*Didymocyrtis cladoniicola* (Diederich, Kocourk. & Etayo) Ertz & Diederich

FIGURE 10B.

*Didymocyrtis cladoniicola* is a lichenicolous coelomycete that was described from Minnesota (Diederich et al. 2007, as *Phoma cladoniicola* Diederich, Kocourk. & Etayo) and has subsequently been reported from Alabama (England et al. 2019) but appears to be widespread in eastern North America based on collections in CNALH (21 December 2021). It was previously reported from one location in Ontario by Brodo et al. (2013). The collections reported here are additional records from new areas of the province.

The species produces tiny black immersed pycnidia on host thalli (Fig. 10B), causing bleaching of the infected hosts, which include members of many genera such as *Cladonia*, *Ramalina*, *Squamarina* and various Parmeliaceae (Ertz et al. 2015). It can be recognized by its host selection, immersed pyriform pycnidia measuring (40–)50–100(–140) µm in diameter and hyaline, ellipsoid conidia measuring (3.8–)4.7–5.9(–7.3) × (2.0–)2.4–3.0(–3.5) µm with a guttule near each apex (Diederich et al. 2007). Another species, *D. foliaceiphila* (Diederich, Kocourk. & Etayo) Ertz & Diederich is also known to infect *Cladonia* species has not been reported from Ontario, though it has been collected nearby in Québec (CNALH 2021) and should be looked for. It can be distinguished from *D. cladoniicola* by the conidia which are more narrowly ellipsoid, measuring (5–)6–7(–7.5) × 2–2.5(–3) µm (Hawksworth et al. 2010). The collections reported here were found growing on the upper surface of the basal squamules of *Cladonia*.

*Specimens examined.* – **CANADA. ONTARIO.** LAMBTON CO.: SE shore of Lake Huron, Pinery Provincial Park, 6 km S of Grand Bend, sandy *Juniperus virginiana* savanna with *Quercus velutina* and *Juniperus communis*, 4.xi.2021, lichenicolous on basal squamules of *Cladonia* sp. among mosses over sand, S.R. Brinker 9231B. PETERBOROUGH CO.: Warsaw Caves Conservation Area, 14 km NW of Norwood, 9.5 km S of Stony Lake, upland *Pinus strobus*, *Thuja occidentalis* and *Abies balsamea* coniferous forest with small openings of Ordovician limestone outcrops, 16.xii.2021, lichenicolous on basal squamules of *Cladonia* sp. on lignum, S.R. Brinker 9204B (CANL); Crowe River Swamp Conservation Reserve, 15 km E of Apsley, lowland mixed forest with *Fraxinus nigra*, *T. occidentalis* and *A. balsamea*, 29.vi.2022, lichenicolous on basal squamules of *Cladonia* sp. on decaying log, S.R. Brinker 9364 (CANL).

*Hypotrachyna revoluta* (Flörke) Hale

Collections of *Hypotrachyna revoluta* from numerous sites in boreal and temperate eastern North America were recently reported by Brinker (2020) (which included the first collections for Ontario) and Lendemer and Allen (2020). Additional records from the Lake Ontario and Lake Erie Basin are provided here. Although considered a locally common species in the southern and central Appalachians, and oceanic areas of the Acadian Forest Region (Lendemer & Allen 2020), it appears to be rare or absent from much of



Ontario (Brinker unpublished data). The collections cited here are noteworthy as the species was not reported from southern Ontario by Wong and Brodo (1992) and thus extend the range of *H. revoluta* in the province south to the Carolinian Zone.

The species can be recognized by its short, ascending secondary lobes, sparse rhizines, and large, subterminal soralia (Lendemer & Allen 2020). It resembles *H. afrorevoluta* (Krog & Swinscow) Krog & Swinscow, which was recently reported for Ontario by Brinker (2020). The latter, however, produces larger thalli and laminal pustules that become erose and usually erode patches of the upper layers of the thallus to reveal the black lower cortex (Lendemer & Allen 2020).

*Specimens examined.* – **CANADA. ONTARIO.** MIDDLESEX CO.: 60 km SW of London, 17.5 km NE of Thamesville, deciduous swamp with *Acer ×freemanii*, *Ulmus americana* and *Cephalanthus occidentalis*, 9.xi.2022, corticolous on bark of fallen *A. ×freemanii*, S.R. Brinker 9685 (hb. Brinker). NORFOLK CO.: Backus Woods Natural Area, 12 km W of Turkey Point, 4 km N of Port Rowan, successional thicket with scattered *Juglans nigra* canopy and conifers, 24.ix.2022, corticolous on twigs of *Picea glauca* S.R. Brinker 9596 (hb. Brinker). NORTHUMBERLAND CO.: N shore of Lake Ontario, Presqu'île Provincial Park, 4 km S of Brighton, treed sand dune with *Juniperus virginiana*, *Populus deltoides*, *Thuja occidentalis* and *J. communis*, 20.x.2020, corticolous on downed *P. deltoides*, S.R. Brinker 8636 (CANL, hb. Brinker). PETERBOROUGH CO.: Crowe River Conservation Reserve 5.5 km ENE of Lasswade, mature mixed swamp with *A. ×freemanii*, *T. occidentalis*, *Fraxinus pennsylvanica*, *Abies balsamea* and *Betula alleghaniensis*, 28.ix.2022, corticolous on twigs of *A. balsamea*, S.R. Brinker 9610 with *A. Smith*, (hb. Brinker).

#### ***Lepra panyrga* (Ach.) Hafellner**

#### **FIGURE 10C.**

*Lepra panyrga* is a circumpolar arctic-alpine species that grows over soil or less frequently on rocks, occurring in North America from Alaska east to Newfoundland and locally south in alpine zones of New England and the Rocky Mountains (Brodo et al. 2001, as *Pertusaria panyrga* (Ach.) Mass.). It was previously known in Ontario from a single collection from Cape Henrietta Maria on James Bay (Dibben 1980, as *P. panyrga*). The record cited below is only the second from the study area where it was collected from maritime tundra on Hudson Bay. It is recognizable by its isidiate to warty thallus with apothecia that are dark, sunken, and covered with grey pruina bordered by a lacerate margin, ascospores that are one per ascus, 90–200 × 35–80 µm, and the absence of positive spot tests (McCune 2017).

*Specimen examined.* – **CANADA. ONTARIO. KENORA DIST.:** Niskibi Cape, 53 km NW of Fort Severn, 8.3 km E of Niskibi River, 8 km S of Hudson Bay coast, tundra ridge with *Rhododendron lapponicum*, *Vaccinium vitis-idaea* and *Empetrum nigrum*, 22.vi.2014, S.R. Brinker 3564 (hb. Brinker).

#### **†*Marchandiomyces corallinus* (Roberge) Diederich & D. Hawksw.**

#### **FIGURE 10D.**

This lichenicolous basidiomycete occurs on a wide variety of host lichens and produces abundant pink to orangish-red convex to subglobose sclerotia that are 100–300 µm in diameter (Hawksworth 1979, as *Illosporium corallinum* Roberge; Molina et al. 2005). The sclerotia erupt through the upper cortex of the host, sometimes appearing superficial (Hawksworth 1979). It is widespread in eastern North America with reports from the southern Appalachians and Ozarks north to Minnesota and Maine (Cole & Hawksworth 2001, Diederich 2003). It was previously reported from Ontario from the Halfway Log Dump area of the Upper Bruce Peninsula (Brodo et al. 2013) and was also recently reported nearby in Aylmer, Québec (Brodo et al. 2021). The additional collections reported here suggest the species is likely more common and widespread in Ontario than current records indicate.

*Specimens examined.* – **CANADA. ONTARIO. ALGOMA DIST.:** Montreal River Harbour area, Lake Superior Provincial Park addition, coniferous forest with *Picea glauca*, *Pinus strobus* and *Thuja occidentalis*, 27.vi.2023, lichenicolous on *Parmelia sulcata* on conifer twigs, S.R. Brinker 10015 & *C. Robillard* (CANL). LENNOX & ADDINGTON CO.: Mount Moriah Conservation Reserve, 22.5 km NNE of Madoc, upland rocky deciduous woods with *Quercus rubra*, *Q. alba* and *Acer saccharum*, 15.vi.2022, lichenicolous on *Physcia thomsoniana* on granite boulder, S.R. Brinker 9418 (CANL). NORFOLK CO.: Backus Woods Natural Area, 5 km SE of Walsingham, 4 km N of Port Rowan, lowland deciduous woods

along creek in valley with *Alnus glutinosa* and *A. ×freemanii*, 29.i.2023, lichenicolous on *P. millegrana* on bark of *A. ×freemanii*, S.R. Brinker 9730 (CANL). PARRY SOUND DIST.: 16 km W of Algonquin Park, 6 km E of Lake Bernard, small *Larix laricina* and *Picea mariana* treed peatland surrounded by upland mixed forest, 21.x.2021, lichenicolous on *Parmelia squarrosa* on twigs of *L. laricina*, S.R. Brinker 9176 (hb. Brinker). PETERBOROUGH CO.: Darling Wildlife Area, 12 km N of Bewdley, 9 km S of Peterborough, deciduous swamp with *A. ×freemanii*, *Fraxinus pennsylvanica* and *Betula alleghaniensis*, 8.xii.2022, lichenicolous on *Parmelia* sp. on bark of *A. ×freemanii*, S.R. Brinker 9708 (CANL).

†*Muellerella hospitans* Stizenb.

FIGURE 10E.

This species appears to be rare or overlooked in North America with previous reports from Alaska and Minnesota (Cole & Hawksworth 2001, Spribille et al. 2010). In Ontario, there is one previous record from the Upper Bruce Peninsula (Brodo et al. 2013). *Muellerella hospitans* is confined to the apothecia of several species of *Bacidia* and *Biatora* (Cole & Hawksworth 2001, Hawksworth et al. 2010) and can be recognized by the ascomata immersed in the host hymenium, and simple, ellipsoid to subglobose ascospores measuring  $2.5\text{--}3.5\text{--}(4) \times (1.5\text{--})2\text{--}2.5$  (Hawksworth et al. 2010). These are the only other reports of the species from Ontario which have so far been restricted to *Bacidia rubella* (Hoffm.) A. Massal.

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: Murphys Point Provincial Park, 13.5 km S of Perth, W of Big Rideau Lake, deciduous swamp with *Fraxinus pennsylvanica* in rocky deciduous forest, 28.iv.2023, lichenicolous on *Bacidia rubella* on *F. pennsylvanica*, S.R. Brinker 9751 (CANL). KENORA DIST.: S shore of Shoal Lake, Elmo Point, 55 km SW of Kenora, lowland deciduous forest with *Acer negundo*, *F. nigra* and *Quercus macrocarpa*, 21.vi.2023, lichenicolous on *B. rubella* apothecia on *F. pennsylvanica*, S.R. Brinker 9946 (CANL). PETERBOROUGH CO.: Squirrel Creek Conservation Area S of Wallace Point Rd. along Otonabee River, deciduous floodplain forest with *Acer ×freemanii*, *F. pennsylvanica* and *Ulmus americana*, 28.ii.2019, lichenicolous on *B. rubella* apothecia on *F. pennsylvanica*, S.R. Brinker 7392A (hb. Brinker); Peterborough County Forest 11.5 km N of Norwood, 6 km W of Round Lake, upland hardwood forest with *Acer saccharum*, *Fraxinus americana* and *Tilia americana*, 4.xi.2022, lichenicolous on *B. rubella* apothecia on *Q. macrocarpa*, S.R. Brinker 9665 (hb. Brinker). RAINY RIVER DIST. Lake of the Woods, Snake Island, 64 km NW of Emo, rich lowland deciduous forest with *F. pennsylvanica*, *U. americana* and *A. negundo*, 17.vi.2023, lichenicolous on *B. rubella* apothecia on *F. pennsylvanica*, S.R. Brinker 9889 (CANL).

†*Refractohilum peltigerae* (Keissler) D. Hawksw.

FIGURE 10F.

This peltigericolous hyphomycete is apparently either very rare or overlooked in North America, with reports from British Columbia (Alstrup & Cole 1998, Goward & Ahti 1992, Noble et al. 1987) and a single report from Ontario (Brodo et al. 2013). Given the lack of published records, the North American distribution is still too poorly known to map. It is a conidial hyphomycete confined to species of *Peltigera* Willd. (Hawksworth 1977). The collections reported here were from humid, productive forests with a cedar component where it grew on the thallus lobes of *Peltigera evansiana* Gyelnik.

*Refractohilum peltigerae* can be identified by its occurrence on *Peltigera*, the formation of reddish-brown gall-like swellings 0.5–5.0 mm wide on the host thallus, and simple, obpyriform to cymbiform hyaline conidia that measure  $15\text{--}25 \times 6\text{--}9 \mu\text{m}$  and are produced on exposed conidiophores that appear as tiny whitish hairs over the surface of the galls (Hawksworth 1977, 1980; Ilhen & Wedin 2008). It is most likely to be confused with *Hawksworthiana peltigericola* (D. Hawksw.) U. Braun, a species inducing similar galls with tiny whitish hairs on *Peltigera*. *Refractohilum peltigerae* can be distinguished by its production of annelidic conidiogenous cells, consistently aseptate conidia with a smaller length:width ratio, and longer and narrower conidiophores (Diederich 2004b).

*Specimens examined.* – **CANADA. ONTARIO.** BRUCE CO.: W side of Georgian Bay, Dyer's Bay, 28 km SE of Tobermory, *Populus tremuloides* – *Thuja occidentalis* – *Betula papyrifera* mixed upland forest over Silurian dolomite with local outcrops, 14.ix.2021, lichenicolous on *Peltigera* sp. on mossy limestone bedrock, S.R. Brinker 9072 (CANL). FRONTENAC CO.: 9 km NE of Plevna, 4.5 km W of Ompah, 800 m E of Mosque Lake, mature mixed swamp with *T. occidentalis*, *Fraxinus nigra* and *Abies balsamea*, 12.ix.2020, lichenicolous on thallus of *P. evansiana* on mossy log, S.R. Brinker 8564 (CANL,



hb. Brinker; conf. D. Hawksworth from photographs); Shawenegog Lake area, 10 km E of Upper Mazinaw Lake, 8 km SW of Plevna, open coniferous swamp with *T. occidentalis*, *Betula alleghaniensis*, *A. balsamea* and *Acer spicatum* surrounded by upland deciduous forest, 14.vii.2021, lichenicolous on *P. evansiana* on mossy log, S.R. Brinker 8859 (hb. Brinker).

***Reichlingia leopoldii* Diederich & Scheid.**

**FIGURE 11A.**

This species was recently collected for the first time in North America from Ontario in Sleeping Giant Provincial Park in the Thunder Bay District (McMullin et al. in prep.) and is not currently on the North America checklist (Esslinger 2021). Until now, its range included portions of Austria, Germany, Great Britain, Lithuania, Luxembourg, Netherlands, Poland, Slovakia and Switzerland (Aptroot 2010, Diederich & Scheidegger 1996, Kukwa 2004, Malíček et al 2014, Motiejūnaitė & Andersson 2003) where it occurs on bark in old-growth forests or on dry calcareous rock walls and underhangs or in crevices. These additional records expand the distributional range of the species significantly to include eastern North America and suggest it may not have been searched for where suitable habitat exists outside its previously understood range. The collections reported here, which include both saxicolous and corticolous material, are noteworthy in that they were from locally humid cedar-dominated woods in a forested valley with extensive limestone exposures, and a coastal forest adjacent to Lake Huron.

*Reichlingia leopoldii* was originally described as a lichenicolous fungus on an unidentified trentepohlioid-containing lichen (Diederich & Scheidegger 1996) though is now treated as a lichenized hyphomycete (e.g., Cannon et al. 2020b). It can be identified by the grey-olive to grey-blue, loosely felt-like thallus with a distinct zonate margin lacking apothecia, dark brown sporodochia occurring in large irregular patches, with multicellular, branched, verrucose conidia constricted at the septa, and a chemistry of 2'-O-methylperlatolic acid and perlatolic acid (Cannon et al. 2020b, Diederich & Scheidegger 1996). The felt-like, blue-green thallus resembles species of *Lepraria* but is distinctive in producing brown conidia on the thallus surface and in having a trentepohlioid photobiont, in addition to its chemistry.

*Specimens examined.* – **CANADA. ONTARIO.** BRUCE CO.: E shore of Lake Huron, 2.5 km S of Pike Bay, coniferous forest with *Thuja occidentalis*, *Abies balsamea* and *Populus tremuloides*, 15.ix.2021, corticolous on *T. occidentalis*, S.R. Brinker 9081 (CANL, hb. Brinker). PETERBOROUGH CO.: Warsaw Caves Conservation Area off Limestone Plains Trail, 12 km E of Lakefield, *T. occidentalis*-dominated coniferous forest with numerous moss-covered limestone boulders and outcrops, 5.v.2020, saxicolous on limestone and overgrowing *Lepraria finkii*, S.R. Brinker 8374 (hb. Brinker, LUX; conf. P. Diederich).

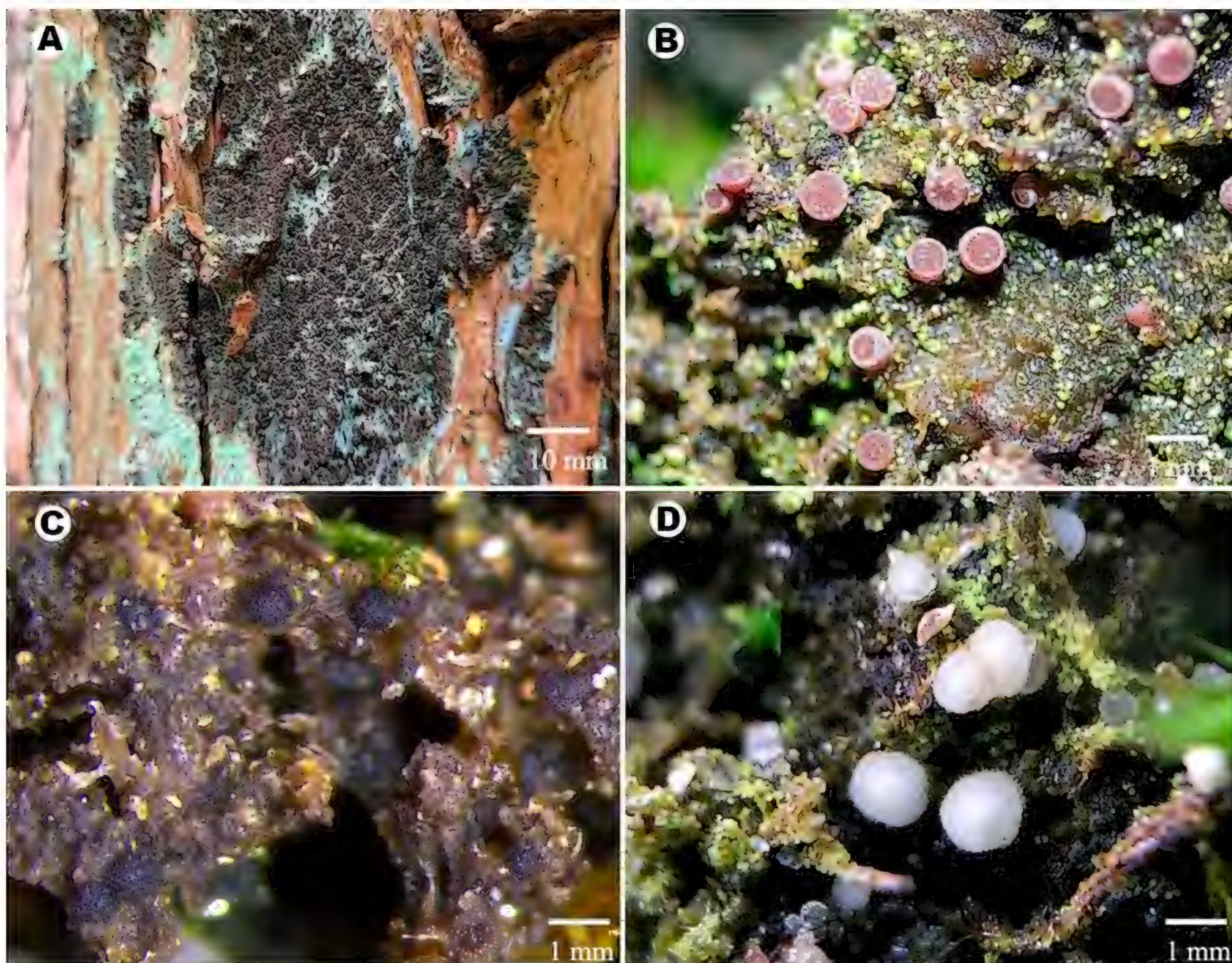
***Sarcosagium campestre* (Fr.) Poetsch & Schiedem.**

**FIGURE 11B.**

*Sarcosagium campestre* is widespread but likely overlooked throughout its North American range, with scattered collections from Alaska, Illinois, Massachusetts, New Brunswick, New Jersey, and Québec (Thomson 1997). In Ontario, the taxon was formerly known from Renfrew County where it was collected on soil over moss in 1986 at Black Donald Lake (Wong & Brodo 1990). The collections reported here are new for their respective regions in the province. It is an ephemeral species of disturbance-maintained habitat appearing during suitably mild and moist conditions on base-rich or acidic consolidated soil and mosses often contaminated with lead or zinc (Cuny et al. 2004, Plantlife 2012), or less frequently on wood, bones, and antlers (Thomson 1997). Its preference for substrates that accumulate heavy metals coupled with the ephemeral nature presumably contributes to the scarcity of collections.

During the present study *Sarcosagium campestre* was found while searching around galvanized electric transmission pylons known for their development of zinc-rich soil (e.g., Buck et al. 1999). The presence of a characteristic lichen flora on metal-enriched soils under electric transmission lines in the Ottawa region was first documented by Brodo (2001) who discovered *Vezdaea leprosa* (P. James) Vězda, *V. acicularis* Coppins and *Steinia geophana* (Nyl.) Stein. *Sarcosagium campestre* can be added to the heavy-metal tolerant lichen community that spontaneously develops in response to elevated levels of zinc in the soil under galvanized metal electric transmission towers. The habitat has hardly been explored in the province, warranting further assessment. The record from Ottawa appears to be new to that region (Brodo et al. 2021).





**Figure 11.** Photographs of lichens rarely reported from Ontario. **A**, *Reichlingia leopoldii* on bark of *Thuja occidentalis* (photo taken in situ, Brinker 9081). **B**, *Sarcosagium campestre* (Brinker 9142). **C**, *Steinia geophana* (Brinker 9297). **D**, *Vezdaea acicularis* (photo taken in situ, Brinker 8583).

*Sarcosagium campestre* can be recognized by its thin, gelatinous, greenish thallus granules when wet, pale red-brown 0.1–0.3 mm diameter apothecia which are translucent when wet, its I+ blue hymenium and hypothecium and polysporous asci which produce simple or occasionally two-celled ellipsoid ascospores that measure  $5\text{--}8 \times 2\text{--}2.3 \mu\text{m}$  (Brodo et al. 2001, Gilbert & Purvis 2009).

*Specimens examined.* – **CANADA. ONTARIO. CITY OF OTTAWA.**: Stony Swamp off Old Richmond Rd., 3.5 km S of Bells Corners, exposed sandstone flatrock under electric transmission line with *Juniperus communis*, *Frangula alnus*, *Solidago nemoralis*, *Fragaria virginiana* and *Danthonia spicata*, 10.x.2021, on moss over sandstone flatrock, S.R. Brinker 9142 (CANL, NY, hb. Brinker). **PETERBOROUGH CO.**: 9.5 km SW of Havelock N of Norwood, successional old-field along esker under electric transmission line, 19.x.2021, on moss over sand under galvanized pylon, S.R. Brinker 9170 (CANL).

#### *Steinia geophana* (Nyl.) Stein

#### FIGURE 11C.

*Steinia geophana* is widespread in North America with records from temperate regions of the East (e.g., Buck et al. 1999, Curtis 2019, Fryday et al. 2001) and scattered records in central and western regions including Arizona (Hafellner 2004), British Columbia (Otto & Ahti 1967), Colorado and South Dakota (McCune 2017). It occurs ephemerally on periodically damp, disturbed soil, decaying wood, vegetation, or over mosses, often polluted by heavy metals (Fletcher et al. 2009). It is very inconspicuous and known in the study area from a single report under a galvanized metal electric transmission pylon (Brodo 2001). The



additional specimens cited below are the only other collections from the province and were similarly found under galvanized towers, two of which were through extensive gneissic rock outcrops.

The species is readily distinguished by its tiny, black, stalked ascomata, multisporous asci with 12 to 16 simple, globose ascospores that measure 5–7  $\mu\text{m}$  in diameter (Hafellner 2004, McCune 2017). Additional records should be expected in the Great Lakes Basin with further searching of similar habitat.

*Specimens examined.* – **CANADA. ONTARIO.** FRONTENAC CO.: Kaladar Jack Pine Barrens Conservation Reserve, along Trans Canada Highway, 7.5 km SW of Kaladar, open acidic rock barren under electric transmission corridor, 14.xi.2021, on mosses under galvanized pylon over bedrock, *S.R. Brinker* 9297 (CANL, hb. Brinker). LENNOX & ADDINGTON CO.: 17 km N of Actinolite, 6 km S of Lingham Lake, exposed granite under electric transmission corridor, 14.vii.2022, on mosses and detritus under galvanized pylon over bedrock, *S.R. Brinker* 9391 (CANL). PETERBOROUGH CO.: Peterborough County Forest 16 km N of Norwood, 7.5 km E of White Lake, open meadow with scattered limestone boulders under managed electric transmission corridor through upland mixed forest, 04.xi.2022, on mosses under galvanized pylon, *S.R. Brinker* 9664 (CANL).

### *Vezdaea acicularis* Coppins

### FIGURE 11D.

This species may be uncommon but is more likely overlooked throughout its North American range which currently includes portions of Alaska, Maine, North Carolina, and Québec, and mainly from substrates contaminated with heavy metals, particularly lead and zinc (Brodo 2001, Buck et al. 1999, Medeiros et al. 2014, Zhurbenko & Laursen 2003). Species of *Vezdaea* are easily unnoticed due to their small size and seasonal development of apothecia which are short lived (Gilbert 1980).

*Vezdaea acicularis* was previously reported from Ontario from a single locality on the Bruce Peninsula where material was collected from upturned soil at the base of a fallen tree (Brodo et al. 2013). Collections of *V. acicularis* during the present study were made from three additional regions of the province and were from compacted sand along a trail through a treed gneissic outcrop and overgrowing mosses under galvanized metal electric transmission pylons. It is the only North America species of *Vezdaea* with multi-celled, needle-like ascospores (Lendemer 2011b).

*Specimens examined.* – **CANADA. ONTARIO.** CITY OF OTTAWA: Anderson Rd., 13 km S of Ottawa River, 10 km SSW of Orleans, moist sandy meadow underneath electric transmission corridor, 13.xi.2021, on mosses, *S.R. Brinker* 9295 (CANL). FRONTENAC CO.: Kaladar Jack Pine Barrens Conservation Reserve, 13 km W of Sheffield Long Lake, 7.5 km NE of Kaladar, extensive ridge and valley gneiss outcrops with upland mixed woods and open barrens and lowland palustrine wetlands, 14.xi.2021, on mosses under electric transmission pylon over bedrock, *S.R. Brinker* 9296 (CANL). LENNOX & ADDINGTON CO.: 17 km N of Actinolite, 6 km S of Lingham Lake, exposed granite under galvanized metal pylon, 14.vii.2022, over moribund bryophytes over bedrock, *S.R. Brinker* 9390 (hb. Brinker). PETERBOROUGH CO.: Kawartha Highlands Provincial Park, 15 km N of Buckhorn, 1.5 km NW of Tamarack Lake, open deciduous woods on granite ridge with *Quercus rubra* and *Acer rubrum*, 27.ix.2020, on compacted acidic sand along trail, *S.R. Brinker* 8583 (CANL, hb. Brinker).

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## Studies in Lichens and Lichenicolous Fungi – No. 23: Notes on Appalachian taxa including newly reported disjunctions and multiple species new to North America

JAMES C. LENDEMER<sup>1,2</sup>

**ABSTRACT.** – *Arthonia ligniariella* is reported for the first time from eastern North America based on a collection growing on lignum in North Carolina, U.S.A. *Biatora appalachensis*, an Appalachian endemic, is shown to be widespread throughout the Appalachian Mountains, primarily at high elevations. The only report of *Fellhanera parvula* from North America (Tennessee, U.S.A.) is considered to be *F. bouteillei*. *Fellhanera subtilis*, previously reported in North America from the Pacific Northwest, is reported for the first time from eastern North America (southern Appalachian Mountains). *Gyalideopsis mexicana*, previously reported in North America from the Yukon, Canada and New Mexico, U.S.A. is newly reported from eastern North America (southern Appalachian Mountains, North Carolina, U.S.A.). *Lepra ouahensis*, a sorediate species with lichexanthone and stictic acid, is reported from disjunct areas of the southern Appalachian Mountains and the Southeastern Coastal Plain. Its distribution is compared to the lichexanthone producing chemotypes of *L. trachythallina* and *Varicellaria velata*. *Rockefellerella crossophylla*, a rare species considered extinct in Pennsylvania, U.S.A. is reported to be extant in that state. *Psoronactis dilleniana* is newly reported from North America from high elevations of the central and southern Appalachian Mountains (North Carolina and Virginia U.S.A.). *Xenonectriella streimannii* is newly reported for North America based on a collection found growing on *Anaptychia palmulata* in Georgia, U.S.A.

**KEYWORDS.** – Biodiversity hotspot, biodiversity inventory, biogeography, floristics, natural history collections.

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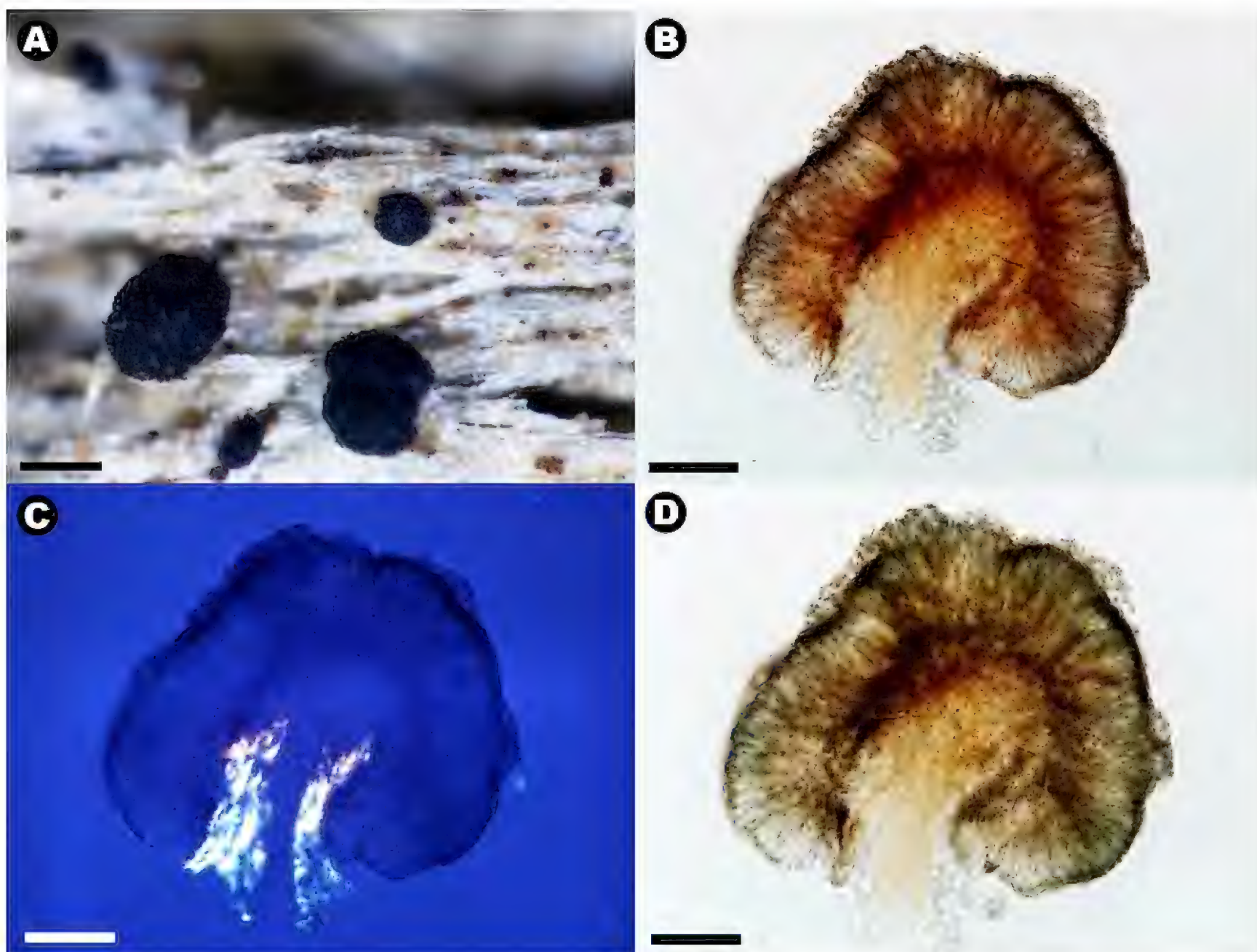
### INTRODUCTION

Routine fieldwork and revision of herbarium specimens often results in the discovery of significant range extensions, occurrences of rare species, and revisions to existing published records. That is even the case for lichens and lichenicolous fungi in relatively well-studied and well-explored areas such as the Appalachian Mountains of eastern North America, where previously undescribed or undocumented species continue to be found at a remarkable rate (e.g., Tripp & Lendemer 2019). The present contribution details six noteworthy range extensions of lichens (*Arthonia ligniariella*, *Biatora appalachensis*, *Fellhanera subtilis*, *Gyalideopsis mexicana*, *Lepra ouahuensis*, *Psoronactis dilleniana*) and one lichenicolous fungus (*Xenonectriella streimannii*) from the Appalachian Mountains of eastern North America. The name *Lepra ouahuensis* is validated and the rediscovery of *Rockefellerella crossophylla* in the northern Appalachians, after more than a century, is documented.

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**Figure 1.** *Arthonia lignariella* (all from Lendemer *et al.* 43492). **A**, morphology of the apothecia illustrating variation from young apothecia with distinct margin to convex with the margin excluded. **B–D**, transverse section of apothecium mounted in water (**B**), in water viewed with polarizing light (**C**) and after treatment with KOH (**D**). Scales = 0.2 mm in **A**, 100  $\mu$ m in **B–D**.

## MATERIALS AND METHODS

This study was based on specimens deposited in the herbarium of the New York Botanical Garden (NY). Georeferenced voucher data for all specimens examined can be accessed through the C.V. Virtual Herbarium at NY (<http://sweetgum.nybg.org/science/vh/>). All specimens were initially studied dry using an Olympus SZ-STB dissecting microscope. Microscopic morphology and anatomy were then studied using an Olympus BX53 compound microscope and sections prepared by hand with a razor blade and mounted in water or iodine. The presence of crystals in the apothecia and thalli were studied using polarizing (POL) filters. Chemistry was studied using standard tests (K, C, KC, P, UV) following Brodo *et al.* (2001) and supplemented by Thin Layer Chromatography (TLC) using Solvents A and C following Culberson and Kristinsson (1970) but as modified for the peanut butter jar by Lendemer (2011a) with Solvent C using the ratio of 200:30 toluene:glacial acetic acid.

### I – ARTHONIA LIGNIARIELLA REPORTED FROM TO EASTERN NORTH AMERICA

*Arthonia* Ach. is a highly diverse, heterogenous assemblage of crustose lichens and allied fungi that includes 158 species which have been reported from North America (Esslinger 2021). Despite the extraordinary diversity, there are still numerous poorly understood and apparently undescribed species known from the region (e.g., Harris & Ladd 2005). Recently Weber *et al.* (2022) drew attention to the discovery of *A. lignariella* Coppins in Finland, and highlighted the occurrence of the species in mature, old-growth forest habitats. The illustrations provided in that publication led to the connection with a



voucher collected in the southern Appalachian Mountains nearly a decade ago. Subsequent study confirmed that the material represents *A. ligniariella* and is the first report of the species from eastern North America.

*Arthonia ligniariella* was described by Coppins (1989) from Scotland based on material collected on a variety of wood substrates, including both hardwoods (*Fagus*, the type; *Quercus*; unidentified hardwoods) and *Pinus*, as well as on bryophytes. It was then reported from the bark of *Thuja* in old growth forests from British Columbia, Canada in western North America (Houde et al. 2007, Spribille & Björk 2008). Thor and Søchting (2018) reported it from Denmark based on records from the branches of *Sambucus*, and from a mature European beech (*Fagus sylvatica*). The mixture of records from old, stable substrates in mature forests, and those from less stable and more frequently disturbed habitats requires further study. The occurrence reported here is from a relatively mature high elevation northern hardwood forest on the wood of an old yellow birch (*Betula alleghaniensis*).

The lignicolous habit, initially plane and eventually convex, black apothecia, reddish-brown pigmented hypothecium, I- hymenium and hyaline, 2-celled ascospores distinguish *A. ligniariella* from most similar species (Coppins 1989; see Figure 1 herein). As was the case for the material reported by Weber et al. (2021) the specimen from North Carolina has ascospores smaller than those reported in the protologue ([7.0]–(7.9)–8.7–(9.6)–[10.6] × [2.1]–(2.3)–2.8–(3.2)–[3.5], n=22 vs. 10.5–14 × 3–3.5 µm reported by Coppins 1989). Despite extensive fieldwork in similar habitats, the species has not been located elsewhere in eastern North America to date.

*Specimen examined.* – U.S.A. NORTH CAROLINA. YANCEY CO.: North Carolina. Pisgah National Forest, Deep Gap just S of camping area, Black Mountain Crest Trail 4.2 mi N of Mount Mitchell, 31 May 2014, on *Betula alleghaniensis* wood, J.C. Lendemer et al. 43492 (NY).

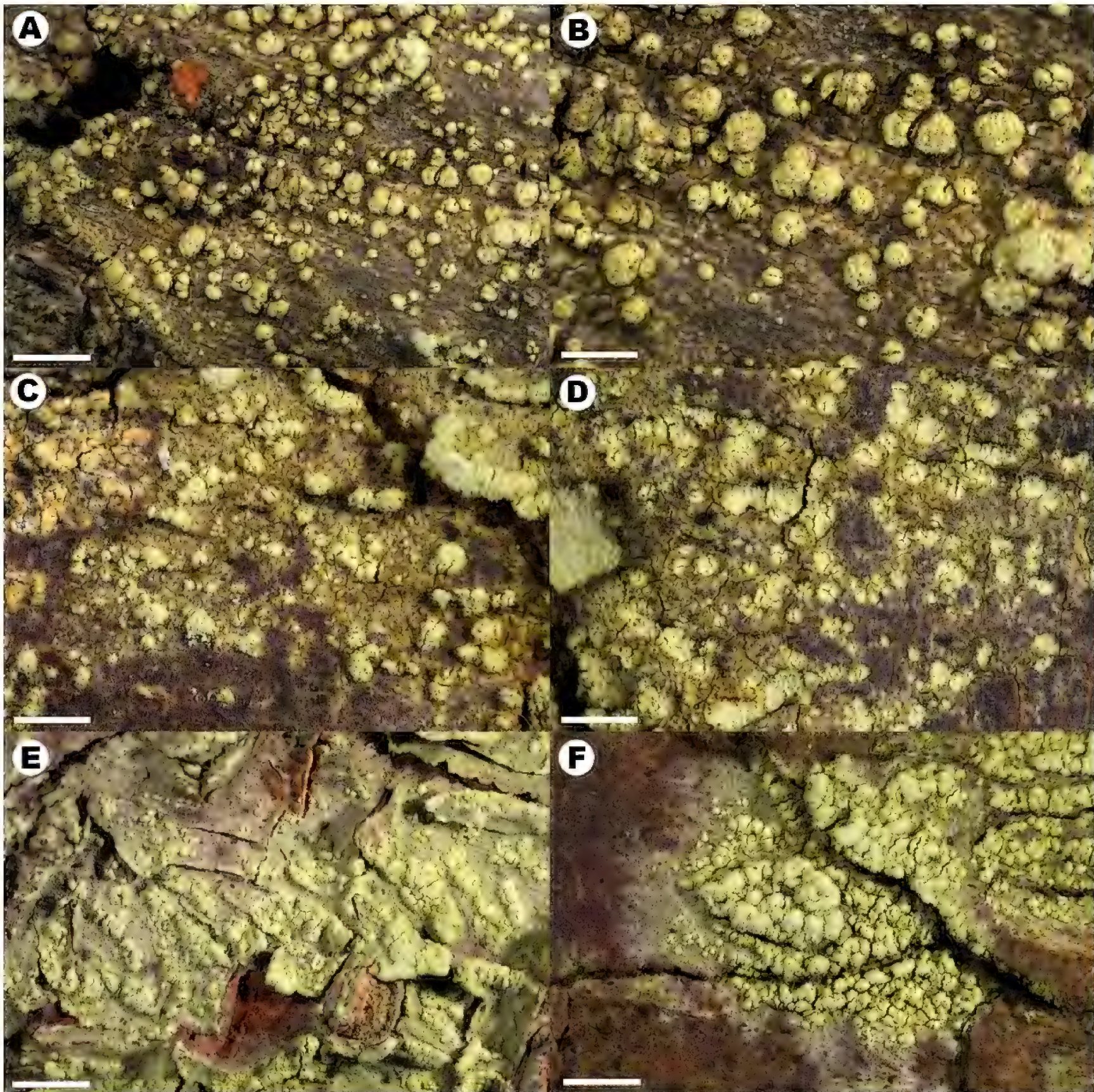
## II – BIATORA APPALACHENSIS OCCURS THROUGHOUT THE APPALACHIAN MOUNTAINS

*Biatora appalachensis* Printzen and Tønsberg was described from high elevations of the southern Appalachian Mountains nearly two decades ago (Printzen & Tønsberg 2004). It is a highly distinctive sorediate crustose lichen that can be recognized by its large, typically convex soralia, bright greenish-yellow soredia (Figure 2), and the presence of only gyrophoric acid (spot tests K-, C+ pink, KC+ pink, P-, UV-; Printzen & Tønsberg 2004). The species has subsequently been found to occur commonly in spruce-fir and northern hardwood forests throughout the southern Appalachian Mountains where it grows on the bark, branches and lignum of both conifers and hardwoods (Tripp & Lendemer 2020). It has also been reported from coastal Maine in New England (Seaward et al. 2017).

Recently the author and several others (Tomas Curtis, Dennis Waters) collected material of this species in areas of its range between Maine and Virginia, U.S.A., especially in the central Appalachians. This led to the review of the holdings of sterile sorediate crustose lichens at NY and to the discovery of many additional occurrences. Here an updated distribution map for *Biatora appalachensis* is provided and specimens that document its extended distribution throughout the Appalachian Mountains are cited (Figure 3). Based on the specimens examined, the species is mostly restricted to high elevations, and is frequently associated with the occurrence of red spruce (*Picea rubens*) and yellow birch (*Betula alleghaniensis*), although it may occur on other substrates in stands that include those species. In Pennsylvania there are a number of collections from eastern hemlock (*Tsuga canadensis*) roots and shaded sandstone outcrops.

*Selected specimens examined.* – U.S.A. GEORGIA. RABUN CO.: Chattahoochee National Forest, S-slopes of Wolf Knob, 23.iv.2019, on *Acer*, J.C. Lendemer 59733 & M.F. Hodges (NY). UNION CO.: Chattahoochee National Forest, slopes above W shore of tributary to Cooper Creek, 9.i.2019, on *Betula*, J.C. Lendemer 57924 & E. Tripp (NY). KENTUCKY. HARLAN CO.: E-slopes of Pine Mountain, Kentenia State Forest, S of Little Shepherd Trail/SR1679 between Mill Cliff Branch and Hi Lewis Branch, 12.iv.2022, on *Quercus* base, J.C. Lendemer et al. 72751 (NY). PERRY CO.: Daniel Boone National Forest, Old Field Branch of Leatherwood Creek, 6.x.2001, on rock, R.C. Harris 44691 (NY). NEW JERSEY. SUSSEX CO.: High Point State Park, Dryden Kuser Natural Area, 1.v.2022, on *Betula*, D.P. Waters 6976 (NY). NORTH CAROLINA. AVERY CO.: Grandfather Mountain State Park, Grandfather Mountain, N-slopes N of Profile Trail, ~0.3 mi W of jct w/ Grandfather Trail, 13.vii.2020, on *Picea* branch, J.L. Allen 5686 (NY). BUNCOMBE CO.: Blue Ridge Parkway, S face of Potato Knob, 2.x.2014, on *Abies* branch, J.C. Lendemer 44236 & J.L. Allen (NY). BURKE CO.: Pisgah National Forest, Linville Gorge Wilderness Area, Jonas Ridge, summit of Gingercake Mountain, 30.vi.2020, on *Kalmia*, J.C. Lendemer 65-

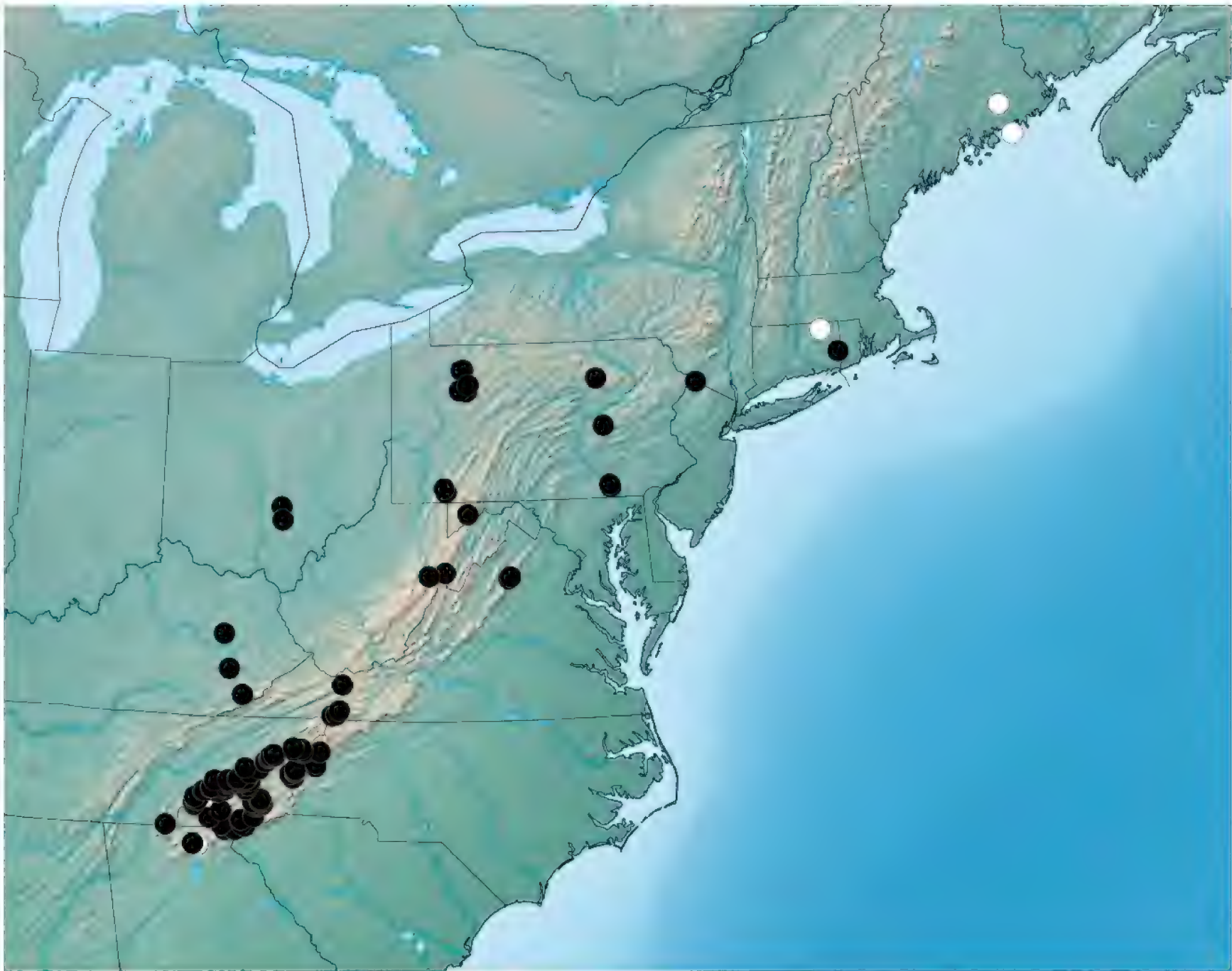




**Figure 2.** Morphology of *Biatora appalachensis* (A & B from *Lendemer* 7715, C & D from *Lendemer* 24548, E & F from *Lendemer* 25124). **A**, gross morphology of typical southern Appalachian individual. **B**, detail of thallus and soralia in southern Appalachian individual. **C and D**, thallus and soralia in central Appalachian individual illustrating circular but less distinctively convex soralia. **E**, central Appalachian individual with soralia becoming contiguous. **F**, central Appalachian individual with closely spaced, convex soralia. Scales = 2.0 mm in A, E and F; 1.0 mm in B–D.

-709 (NY). GRAHAM CO.: Nantahala National Forest, Joyce Kilmer-Slickrock Wilderness Area, Stratton Bald Trail 0–0.25 mi SW of Naked Ground, 19.vi.2015, on large *Betula*, *J.C. Lendemer* 45832 & *J.L. Allen* (NY). HAYWOOD CO.: Great Smoky Mountains National Park, Balsam Mountain, Beech Gap, N of Ledge Bald, 18.vi.2019, on *Picea* branch, *J.C. Lendemer et al.* 60327 (NY). JACKSON CO.: Blue Ridge Parkway, Richland Balsam, ~0.25 mi NW of Haywood Jackson Overlook, 4.vi.2014, on *Prunus*, *J.L. Allen* 2943 (NY). MACON CO.: Nantahala National Forest, Southern Nantahala Wilderness, ~3 mi N of Tate City, 17.ix.2006, on *Betula*, *J.C. Lendemer et al.* 7715 (NY). MADISON CO.: Pisgah National Forest, Bald Mountains, S-slopes of Spring Mountain, 17 Aug. 2020, on log, *J.C. Lendemer* 69241 (NY). MITCHELL CO.: Pisgah National Forest, Roan Mountain, Grassy Ridge Bald above Chimney End Ridge, 28.vii.2020, on *Abies*, *J.C. Lendemer* 67706 (NY). SWAIN CO.: Great Smoky Mountains National Park, N-facing slopes of High Rocks, High Rock Ridge, 29.v.2019, on large *Betula*, *J.C. Lendemer* 62992 & *R. Walston*

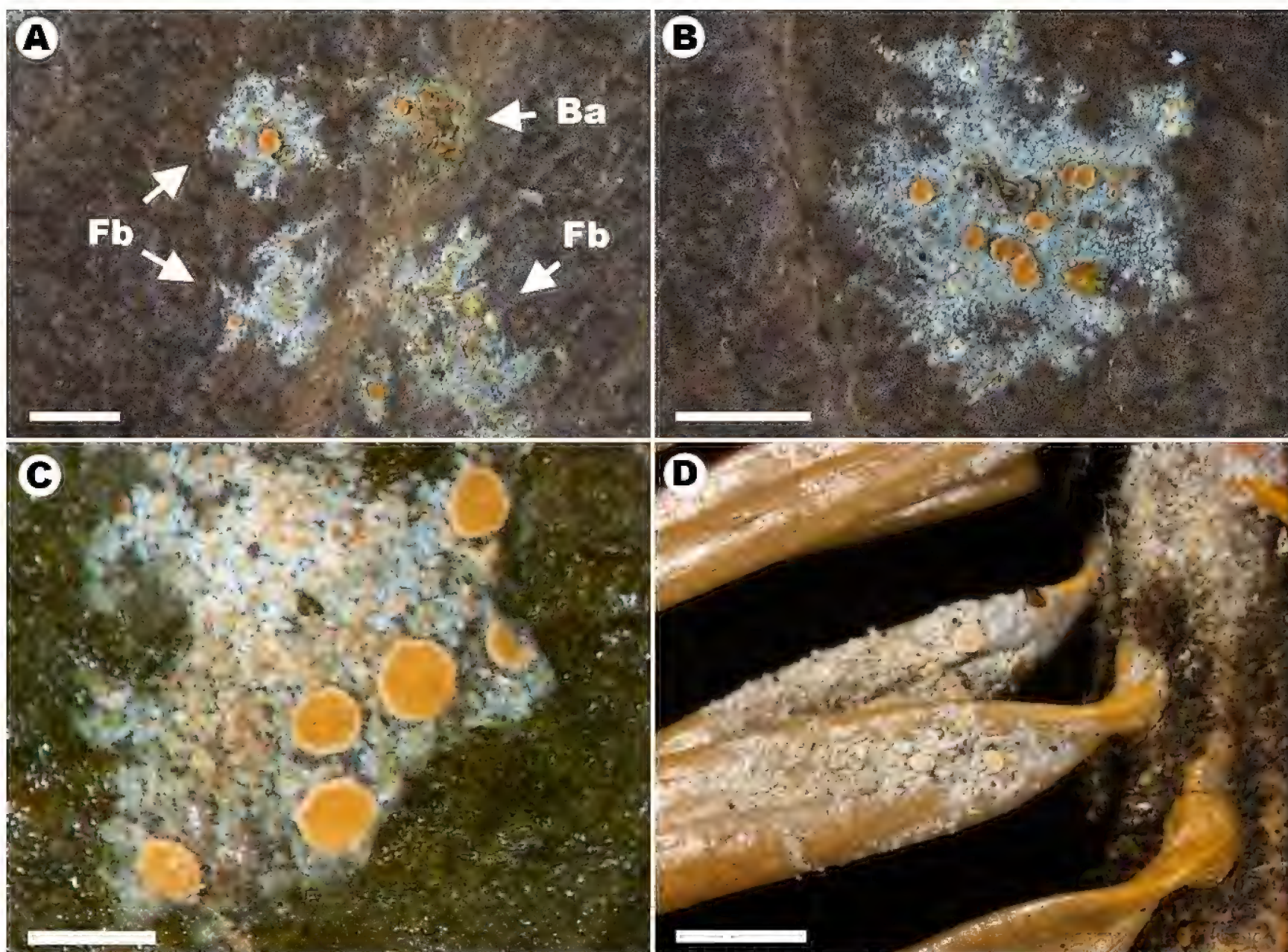




**Figure 3.** Known geographic distribution of *Biatora appalachensis* based on specimens examined for this study including those from collaborators T. Curtis and D.P. Waters (black dots), and records in the Consortium of North American Lichen Herbaria (CNALH, white dots, downloaded 25 November 2022).

(NY). WATAUGA CO.: Grandfather Mountain State Park, Grandfather Mountain, S slopes of Calloway Peak, 13.vii.2020, on *Abies* branch, J.C. Lendemer et al. 66660 (NY). YANCEY CO.: Pisgah National Forest, Craggy Mountains, W-slopes of Big Butt, Brush Fence Ridge, 5.vii.2020, on fallen *Picea* branch, J.C. Lendemer 66345 (NY). PENNSYLVANIA. CLARION CO.: Cook Forest State Park, Rhododendron/Indian Trail Loop, 6.ix.2010, on *Tsuga* root, J.C. Lendemer 24548 (NY). ELK CO.: Allegheny National Forest, FR131 1.25 mi SW of jct w/ FS228, 9.ix.2010, on *Tsuga* root, J.C. Lendemer 25124 (NY). FAYETTE CO.: Ohiopyle State Park, Cucumber Falls/Great Gorge Trail, 30.iv.2018, on *Betula*, D.P. Waters 3264 (NY). JEFFERSON CO.: Clear Creek State Park, Phyllis Run 0.25–0.75 mi N of confluence w/ Clear Creek, 8.ix.2010, on *Picea* root, J.C. Lendemer 24782-A (NY). NORTHUMBERLAND CO.: Wildlife Preserve, ca. 2.5 mi W of Alaska, S of PA 901, 20.v.2009, on *Acer*, J.C. Lendemer 17665 & R.C. Harris (NY). SULLIVAN CO.: Worlds End State Park, along Mineral Spring Rd. ~0.25 mi from int. w/ PA154, 18.iv.2004, on sandstone, J.C. Lendemer 2196 & J.A. Macklin (NY). YORK CO.: Apollo County Park, N section via Boyd Road Access, 9.viii.2009, on *Betula* root, J.C. Lendemer 19425 (NY), on rock, J.C. Lendemer 19452 (NY); State Game Lands No. 83, S shore of Sawmill Run, 9.viii.2009, on rock, J.C. Lendemer 19379 (NY). TENNESSEE. BLOUNT CO.: Great Smoky Mountains National Park, ridge E of Little River Gorge Rd., ~3.7 mi NE of jct w/ TN73, 9.xii.2017, on *Amelanchier*, J.C. Lendemer et al. 53802 (NY). CARTER CO.: Cherokee National Forest, N-slopes of Roan Mountain, Round Bald, 19.iii.2018, on *Picea*, J.C. Lendemer 56121 & E. Tripp (NY). COCKE CO.: Cherokee National Forest, Stone Mountain, W-facing slopes of Hall Top, 19.x.2018, on *Acer* root, J.C. Lendemer 56789 (NY). MONROE CO.: Cherokee National Forest, Unicoi Mountains, Bob Bald, Benton MacKeye Trail/Bob Bald Connector/Trail54A, 18.xii.2017, on *Betula*, J.C. Lendemer 54753 & E. Tripp (NY). POLK CO.: Cherokee National Forest, Big Frog Wilderness Area, E-slopes of Bark Logging Lead of





**Figure 4.** Comparison of voucher cited as *Fellhanera parvula* (A and B, Pursell 3399) to reference specimens of *F. bouteillei* from Central America (C, Lücking 92-9205, NY) and Europe (D, Lettau 207, NY). Note admixture of *F. bouteillei* (“Fb”) and *Bacidia apiahica* (“Ba”) in A. Scales = 2mm in D, 1.0 mm in A and B, 0.5 mm in C.

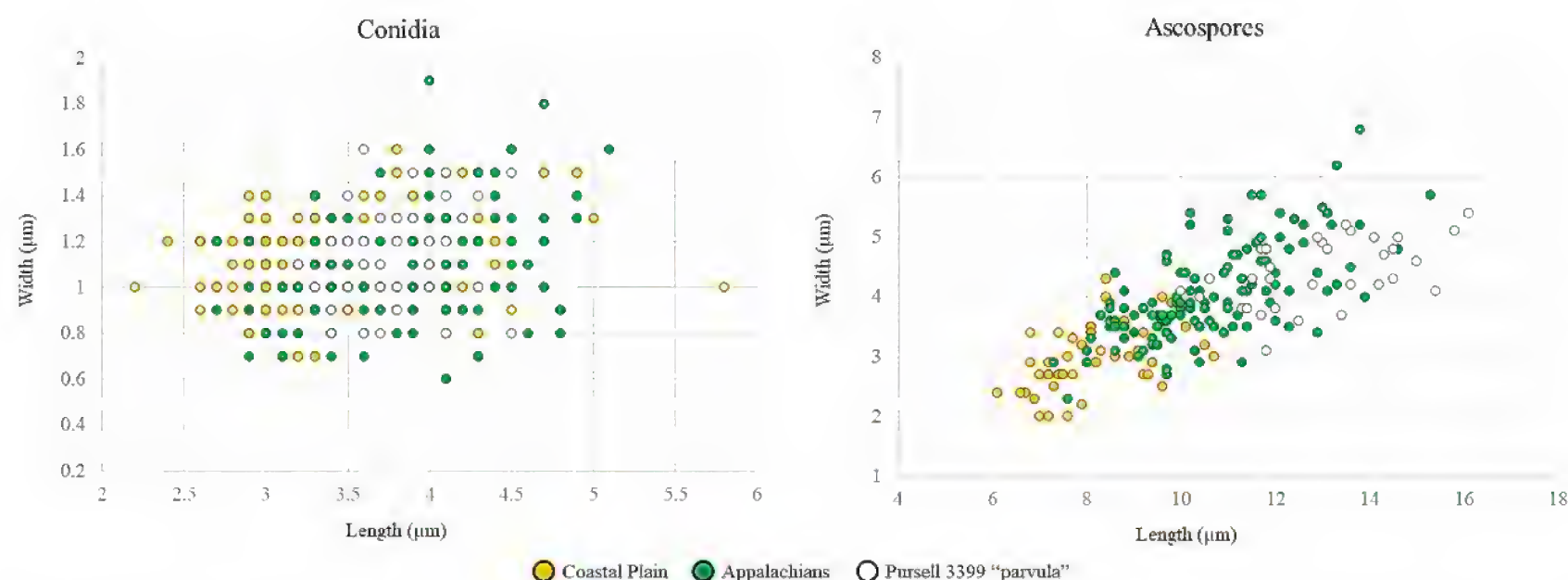
Big Frog Mountain, 16.xii.2017, on *Betula*, J.C. Lendemer 54462 & E. Tripp (NY). SEVIER CO.: Great Smoky Mountains National Park, Mount LeConte, N-facing slopes above Trillium Gap Trail, 24.x.2018, on *Sorbus*, J.C. Lendemer 57108 (NY). UNICOI CO.: Cherokee National Forest, Unaka Mountain, areas just N of Unaka Mountain Wilderness, Dark Hollow Trail/Trail #32, 8.iii.2018, on *Tsuga* root, J.C. Lendemer 55152 & E. Tripp (NY). VIRGINIA. GRAYSON CO.: Jefferson National Forest, 0.5 mi SW of VA 16 on VA 741/Homestead Rd., 5.iv.2008, on *Acer*, R.C. Harris 54023 (NY). MADISON CO.: Shenandoah National Park, Central District, Hemlock Springs talus, 24.iv.2021, on large *Betula* root, J.C. Lendemer 70467 (NY). PAGE CO.: Shenandoah National Park, Central District, W slopes of The Pinnacle, 15.x.2020, on *Kalmia*, J.C. Lendemer 70271 (NY). SMYTH CO.: Jefferson National Forest, Whitetop Mountain, 6.iv.2008, on *Picea* branch, R.C. Harris 54084 (NY).

### III – FELLHANERA PARVULA EXCLUDED FROM NORTH AMERICA

The majority of *Fellhanera* species that have been reported from North America are corticolous, lignicolous or saxicolous (Harris & Lendemer 2009). While many foliicolous species are known to exist (Lücking 2009), only *F. bouteillei* (Desm.) Vězda and *F. subtilis* (Vězda) Diederich & Sérus. are currently included on the North American lichen checklist (Esslinger 2021). The former is widespread in humid subtropical and temperate areas of North America, where it grows on the leaves of evergreen shrubs and trees, as well as on conifer needles and branches (McCune 2017, Tripp & Lendemer 2020). The latter species has been reported from the Pacific Northwest (Goward et. al. 1996) and is newly reported from eastern North America below.

While keying out foliicolous lichens from the southern Appalachian Mountains using Lücking (2009), the first author noticed a cited specimen of *F. parvula* (Vězda) Vězda from eastern Tennessee, USA





**Figure 5.** Graphical comparison conidium (left) and ascospore (right) size in material of *Fellhanera bouteillei* from the Coastal Plain of southeastern North America (orange points), southern Appalachian Mountains (green points) and specimen cited as *F. parvula* (Pursell 3399, white points).

(R.A. Pursell 3399, NY; Lücking 2009: 649). Evidently the report had been overlooked, as *F. parvula* does not appear in Esslinger (2021). This led to the question of whether *F. parvula* was present and widespread in the southern Appalachians, having been previously confused with *F. bouteillei*. The two species are similar in having pallid to slightly yellowish apothecia, and differ slightly in the size of the conidia ( $3\text{--}4 \times 1\text{--}1.5 \mu\text{m}$  in *F. parvula* vs.  $4\text{--}5 \times 1.5\text{--}2 \mu\text{m}$  in *F. bouteillei*), apothecia ( $0.1\text{--}0.4 \text{ mm}$  in diameter  $\times 70\text{--}120 \mu\text{m}$  high in *F. parvula* according to description on p. 649 but  $0.08\text{--}0.2 \text{ mm}$  in diameter according to the key on p. 629) vs.  $0.2\text{--}0.4 \text{ mm} \times 100\text{--}150 \mu\text{m}$  high in *F. bouteillei*) and ascospores ( $6\text{--}14 \times 2\text{--}4 \mu\text{m}$  in *F. parvula* vs.  $10\text{--}17 \times 3\text{--}6 \mu\text{m}$  in *F. bouteillei*) (all *fide* Lücking 2009: 648 and 649). According to Lücking (2009: 249), in addition to the slight size differences outlined above, *F. parvula* has a green thallus that should lack usnic acid, while that of *F. bouteillei* is blue-gray and produces usnic acid together with zeorin (Figure 4).

The voucher cited as *Fellhanera parvula* by Lücking (2009) was filed at NY as *F. bouteillei* and had not been annotated as *F. parvula*. The specimen includes multiple thalli of a *Fellhanera* that resemble *F. bouteillei*, as well as fewer, scattered thalli that differ in having minute, dark yellow-orange biatorine apothecia and a poorly-developed, dark green thallus. Initially it seemed that the latter could be *F. parvula*, but microscopic examination revealed hyaline, acicular ascospores and that the thalli belong to *Bacidia apiahica* (Müll. Arg.) Zahlbr. (see Lücking 2009;  $\equiv$  *Bacidina apiahica* (Müll. Arg.) Vězda). The thalli of *Fellhanera* from Pursell 3399 were compared to collections of *F. bouteillei* from the southern Appalachians, the Coastal Plain of southeastern North America, and Europe. The size ranges for the morphological characters of Pursell 3399, as well as the eastern North American specimens of *F. bouteillei* examined, match those reported for the latter species and not for *F. parvula* (Figure 5). The size ranges of the eastern North American material also match that of European reference specimens of *F. bouteillei*. In addition, the thalli in Pursell 3399 produce usnic acid and zeorin, which was confirmed with comparative TLC using other vouchers of *F. bouteillei* from Tennessee. Based on the above, I conclude that the voucher cited by Lücking (2009) corresponds to *F. bouteillei* and that *F. parvula* should not be included in the North American checklist at present.

*Selected specimens examined.* – **LITHUANIA.** TELŠIAI: Zemaitija National Park, Plunge district, Polkstone, 1.vii.2003, on *Picea* twigs and needles, J. Montiejunaite 6876 (NY). **U.S.A. GEORGIA.** CHATHAM CO.: Wormsloe State Historic Site, 4.xi.2011, on *Sabal* leaf, M.F. Hodges 7686 (NY). MISSISSIPPI. FORREST CO.: Ragland Hills, S of the Leaf River, 17.iii.2022, on *Sabal* frond, J.C. Lendemer 72538 (NY). GEORGE CO.: Harvell & Pellerree Jackson Sandhills TNC Preserve, 15.iii.2022, on *Serenoa* frond, J.C. Lendemer 72440 (NY). WAYNE CO.: De Soto National Forest, Brewertown Sandhill, 14.iii.2022, on *Ilex vomitoria* leaves, J.C. Lendemer 72006 (NY). NORTH CAROLINA. CRAVEN CO.: Croatan National Forest, Still Gut 0–0.5 mi SW of FS3046/Hope Rd., 6.iii.2013, on *Sabal* leaf, J.C. Lendemer et al. 35404 (NY). DARE CO.: Buxton Woods Coastal Reserve, SE of jct of Great





**Figure 6.** Thallus and apothecia *Fellhanera subtilis* from the southern Appalachian Mountains, U.S.A. (both from *Lendemer 66462*). Scales = 0.5 mm in A, 0.2 mm in B.

Ridge Rd. and Water Association Rd., E of West Trail, 18.viii.2013, on *Sabal* leaf, *J.C. Lendemer 35965* (NY). HAYWOOD CO.: Great Smoky Mountains National Park, Cataloochee, vicinity of Caldwell House, 20.x.2012, on *Rhododendron* leaves, *J.C. Lendemer 33327* & *A. Moroz* (NY). JACKSON CO.: Nantahala National Forest, Ellicott Rock Wilderness, E shore of Chattooga River downstream of confluence with Fowler Creek, 5.vi.2018, on *Leucothoe* leaves, *J.C. Lendemer 56511* (NY). MACON CO.: Nantahala National Forest, E side of Chattooga River 0.25–0.75 mi N of FSR1178/Bull Pen Rd., 25.vi.2016, on *Rhododendron* leaves, *J.C. Lendemer 47310* (NY). MADISON CO.: Pisgah National Forest, Shelton Laurel, along Big Creek Road near Fork Ridge Trailhead, 7.viii.2020, on *Rhododendron* leaves, *J.P. Hollinger et al. 24132* (NY). SWAIN CO.: Great Smoky Mountains National Park, Forney Creek Trail, between crossing over Bear Creek and jct with Lakeshore Trail, 29.vi.2010, on *Rhododendron* leaves, *J.C. Lendemer et al. 23553* (NY). SOUTH CAROLINA. BEAUFORT CO.: Spring Island, NW side, 0–0.25 mi S of Shrimp Pond Rd., 21.xii.2013, on *Sabal* leaf, *J.C. Lendemer et al. 42437* (NY). OCONEE CO.: Sumter National Forest, Ellicott Rock Wilderness, low S-facing slopes of Fork Mountain, 18.iv.2019, on *Rhododendron* leaf, *J.C. Lendemer 58944* (NY). TENNESSEE. CARTER CO.: Cherokee National Forest, N-slopes of Roan Mountain, Round Bald, 19.iii.2018, on *Abies* branch, *J.C. Lendemer 56136* & *E. Tripp* (NY). GREENE CO.: Cherokee National Forest, Gravel Knob, 7.viii.2020, on *Rhododendron* leaves, *J.P. Hollinger et al. 24136* (NY). SEVIER CO.: Great Smoky Mountains National Park, Alum Cave Parking Area, ca. 6 mi S.E. of Gatlinburg, 14.ix.1958, on *Rhododendron* leaves, *R.A. Pursell 3399* (NY, cited as *Fellhanera parvula* by Lücking 2009). UNICOI CO.: Cherokee National Forest, Unaka Mountain, W-facing slopes above Red Fork Rd./FSR230, 17.iii.2018, on *Rhododendron* leaves, *J.C. Lendemer 55910* & *E. Tripp* (NY).

#### IV – FELLHANERA SUBTILIS REPORTED FROM EASTERN NORTH AMERICA

*Fellhanera subtilis* was originally described from the Czech Republic as *Bacidia subtilis* (Vězda 1961) and transferred to *Fellhanera* by Sérusiaux (1990). It is a corticolous and foliicolous crustose lichen that has been reported from many areas of Europe (Belgium: Sérusiaux 1990; Belarus: Yatsyna & Motiejūnaitė 2015; Denmark: Søchting et al. 1992; Estonia: Marmor et al. 2013; Finland: Harmaja 1995; Greece: Christensen 2018; Italy: Tretiach 1992; Lithuania: Motiejūnaitė 1995; Poland: Miadlikowska 1997, Wegrzyn 2002; Romania: Vondrák & Liska 2013; Sweden: Zhurbenko & Nordin 2020; The Netherlands: Spier 1994). It has also been reported from central Asia (Davydov & Printzen 2012) and eastern Asia (Aptroot & Moon 2014, Kondratyuk et al. 2015). In North America it has been reported only from the Pacific Northwest in Canada (Goward et al. 1996).

During fieldwork in the southern Appalachian Mountains, *Fellhanera subtilis* was found at several sites in mature, high elevation spruce-fir forests where it grew on the young branches of Fraser Fir (*Abies fraseri*) in close association with *F. bouteillei*. While the latter species is superficially similar to *F. subtilis*, it differs in having a granular (vs. smooth) thallus, usually yellowish (vs. pallid) apothecia, and 2-celled (vs. 4-celled) ascospores (Figure 6 herein; Lücking 2009, Vězda 1961). Interestingly, in the southern Appalachians, *F. bouteillei* is primarily foliicolous (Tripp & Lendemer 2020) and when growing with *F. subtilis* was largely restricted to the needles of the phorophyte, rather than the adjacent bark of the



branches. The reports of *F. subtilis* published here extend its range a considerable distance into southeastern North America where it likely belongs to a suite of species with oceanic distributions in Europe and northern North America, but which are disjunct to high elevations of the southern Appalachian (see Tripp & Lendemer 2019).

*Specimens examined.* – **GERMANY.** BAVARIA. BAYERN: Niederbayern, Lkr. Freyung-Grafenau, National Park Bayerischer Wald, 0.3–0.4 km SW of lake Rachel-See, 13.x.1999, on *Vaccinium*, *T. Tønsberg* 28199 (NY). **LITHUANIA.** UTENA: Aukštaitija National Park, Ignalina district, ca. 4 km S of Ginučiai village, 28.vi.1995, *J. Montiejunaite* 2674 (NY). **POLAND.** Pojezierze Kaszubskie, Stanisławskie Bloto Nature Reserve, 20.ix.1998, on *Vaccinium*, *W. Faltynowicz s.n.* (NY). **U.S.A.** NORTH CAROLINA. HAYWOOD CO.: Great Smoky Mountains National Park, S slopes of Big Cataloochee Mountain, between Balsam Corner and Big Butt, 6.vii.2020, on *Picea* branch, *J.C. Lendemer* 66462 & *J. Hollinger* (NY). MITCHELL CO.: Pisgah National Forest, Roan Mountain, Grassy Ridge Bald above Chimney End Ridge, 28.vii.2020, on *Abies* branch, *J.C. Lendemer* 67732 (NY). TENNESSEE. SEVIER CO.: Great Smoky Mountains National Park, Mount LeConte, N-facing slopes above Trillium Gap Trail, 24.x.2018, on *Abies* branch, *J.C. Lendemer* 57088 (NY).

#### V – GYALIDEOPSIS MEXICANA NEW TO EASTERN NORTH AMERICA

*Gyalideopsis mexicana* Tretiach, Giralt & Vězda was originally described from montane central Mexico in South America (Hafellner 2016, Tretiach et al. 1996). It is a very distinctive species with large, pale, stalked hyphophores and diahyphae aggregated in a conspicuous globose mass at the apex (Tretiach et al. 1996; Figure 7 herein). The distribution of this unusual species is poorly understood, and it has subsequently been reported growing over mosses in the Yukon, Canada (Lendemer 2011b) and on organic matter or soil at high elevations of New Mexico in the United States (Lendemer & Tripp 2014). During recent fieldwork in Great Smoky Mountains National Park, the species was found growing abundantly over mosses on one large boulder at a remote site in Swain County, North Carolina. The southern Appalachian Mountains of eastern North America are widely recognized as a biodiversity hotspot for lichens, including many disjunct species (Sheard et al. 2012, Tripp & Lendemer 2019). Nonetheless the discovery of *G. mexicana* was quite unexpected, and this is the first report of the species from eastern North America.

*Specimen examined.* – **U.S.A.** NORTH CAROLINA. SWAIN CO.: Great Smoky Mountains National Park, N-facing slopes of High Rocks, High Rock Ridge, 29.x.2019, on rock, *J.C. Lendemer* 63027 & *R. Walston* (NY).

#### VI – LEpra OUAHUENSIS NEW TO NORTH AMERICA

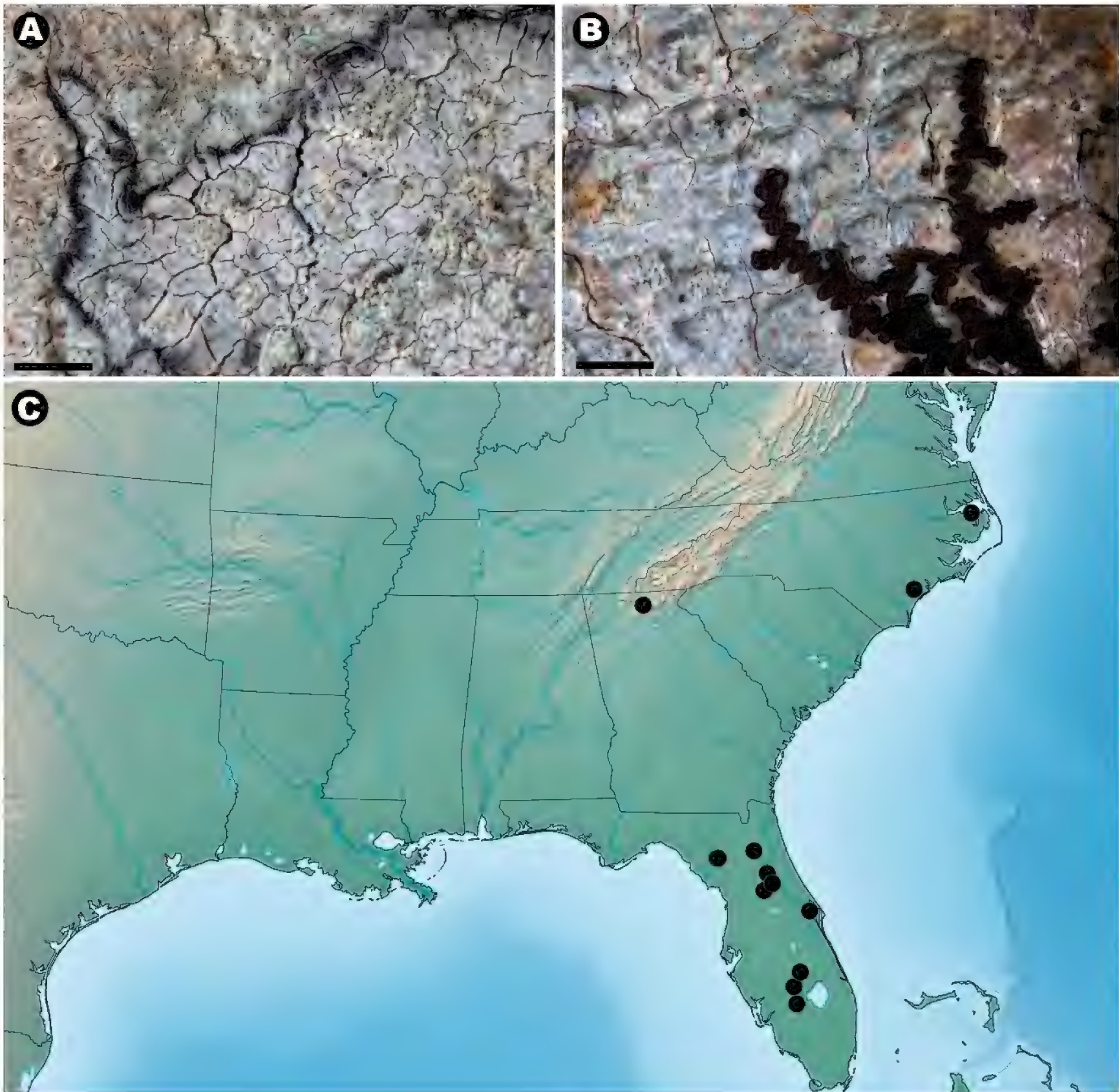
Recently, Paul Diederich contacted the author regarding the identity of a sterile sorediate crustose lichen that hosted an undescribed lichenicolous basidiomycete, now described as *Tremella leprae* Diederich (Diederich et al. 2022). The lichen produced lichexanthone and stictic acid, two substances that are rarely found together in North American lichens (Lendemer, unpublished data). The specimen was collected in the southern Appalachian Mountains of Georgia, U.S.A. at a high elevation site that had been visited by the author. It also matched an unidentified voucher at NY that had been collected elsewhere in northern Georgia (*Tripp* 9112-A). Review of the literature led to *Lepra ouahuensis* H. Magn. ex Bungartz, A.W. Archer & Elix, a species described from Hawaii, U.S.A. and not apparently yet reported from outside of that region. Material with the same chemistry was reported from Florida, U.S.A. by Harris (1995: 51) as *Pertusaria* “sp. Buck 16889” and has been found at scattered locations throughout the Mid-Atlantic Coastal Plain of southeastern North America (Figure 8). It appears all the North American collections represent one species that is distributed in the Coastal Plain with a disjunct population at high elevations in the southern Appalachian Mountains (Figure 8). Although on the surface this disjunction may seem unusual, the lichexanthone producing variants of *Lepra trachythallina* (Erichsen) Lendemer & R.C. Harris and *Varicellaria velata* (Turner) I. Schmitt & Lumbsch also have similar distribution patterns (Figure 9). *Lepra ouahuensis* is here reported for the first time from North America, the presence in this region suggests that it may be more widespread in tropical and subtropical regions than has previously been recognized.





**Figure 7.** *Gyalideopsis mexicana* (all from *Lendemer 63027*, NY). **A**, gross morphology of the thallus and hyphophores. **B–D**, detail of the hyphophores. **E** and **F**, detail of the apical mass of diahyphae. Scales = 2.0 mm in **A**, 1.0 mm in **B–E** and 0.5 mm in **F**.

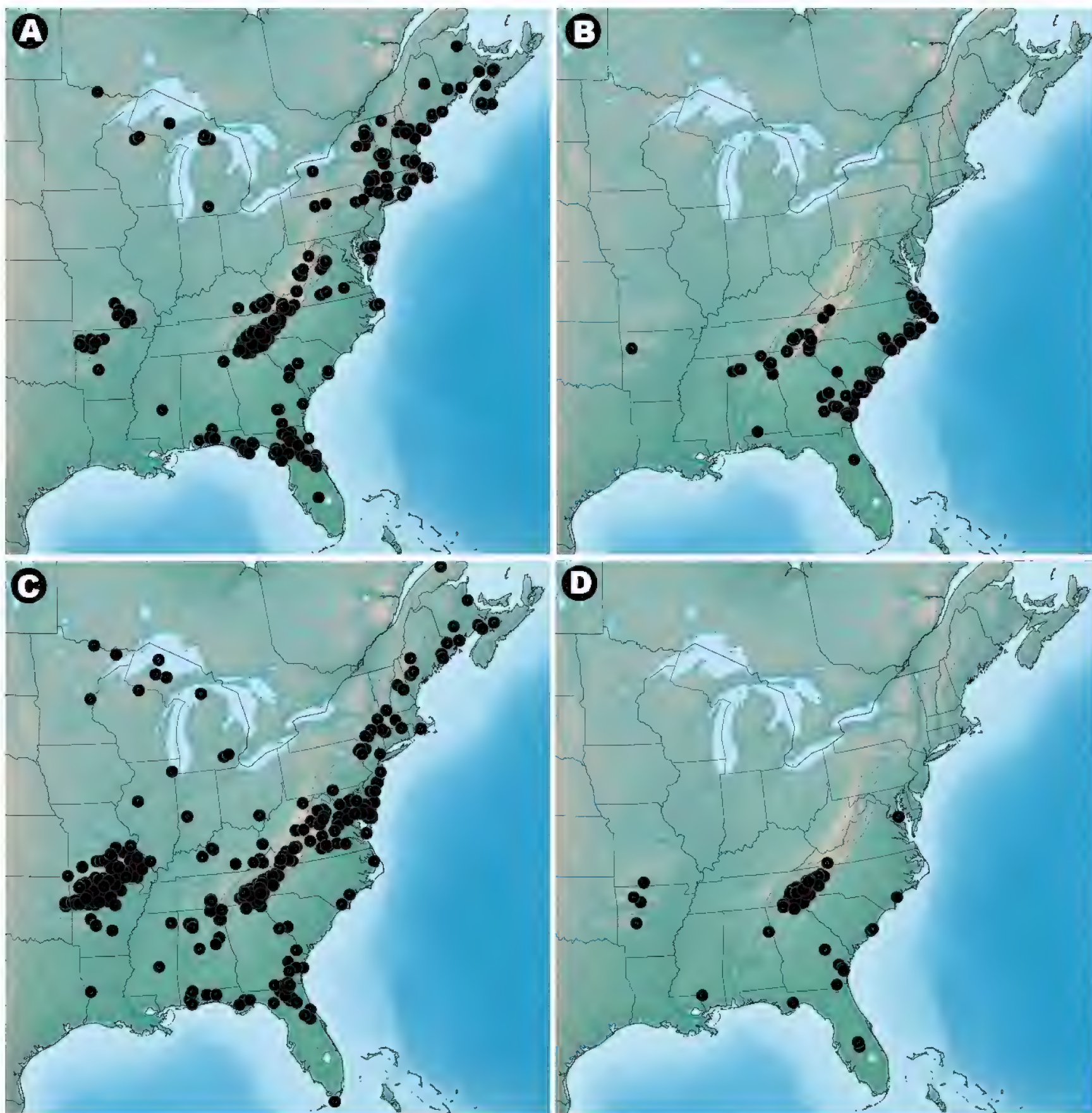




**Figure 8.** North American *Lepra oahuensis*. **A**, gross morphology of the thallus and soralia (*Lendemer* 43039, NY). **B**, detail of thallus and soralia (*Lendemer* 38869, NY). **C**, distribution of *L. oahuensis* in North America based on specimens examined for this study at NY. Scales = 1.0.

*Additional specimens examined.* – U.S.A. FLORIDA. BREVARD CO.: Corner of Fox Lake Road and South Carpenter Road, just W of St. Rd. 405 and I-95, 7.i.1996, on *Lyonia*, *R.C. Harris* 37841 (NY). CLAY CO.: Gold Head Branch State Park, 28.xi.1992, on Ericaceae, *R.C. Harris* 29153 (NY). GILCHRIST CO.: Waccasassa Flats, along Co. Rd. 232 ca. 1 mi W of St. Rd. 47, 5.xii.1993, on *Prunus*, *R.C. Harris* 31730 (NY). GLADES CO.: Ortona Cemetery, along SR 78, 1 mi E of CR 78A, 30.iii.1998, on *Lyonia*, *R.C. Harris* 42100 (NY). HIGHLANDS CO.: Hickory Hammock, 28.iii.1998, on *Ilex*, *R.C. Harris* 41923 (NY); Archbold Biological Station, on Old SR 8, W boundary fire lane of SE Tract, 26.iii.1998, on *Quercus*, *R.C. Harris* 41795 (NY). MARION CO.: Ocala National Forest, along FL40, 2 mi E of FL19, 2.i.1996, on bark, *E. Lay* 96-0020 (NY). GEORGIA. FANNIN CO.: Chattahoochee National Forest, ravine of tributary to Toccoa River, Toccoa River Rd./FSR333 0.7 mi NW of jct w/ Rocky Creek Rd./FSR69, 5.i.2019, on *Betula*, *E. Tripp* 9112-A & *J.C. Lendemer* (NY). NORTH CAROLINA. PENDER CO.: Holly Shelter Game Land, S portion of Shaken Creek floodplain, 27.x.2013, on *Magnolia*, *J.C. Lendemer et al.* 38869 (NY). TYRRELL CO.: Alligator River Game Land, Middle Rd. 0–0.25 mi NE of US64, 22.iii.2014, on *Acer*, *J.C. Lendemer* 43039 (NY).



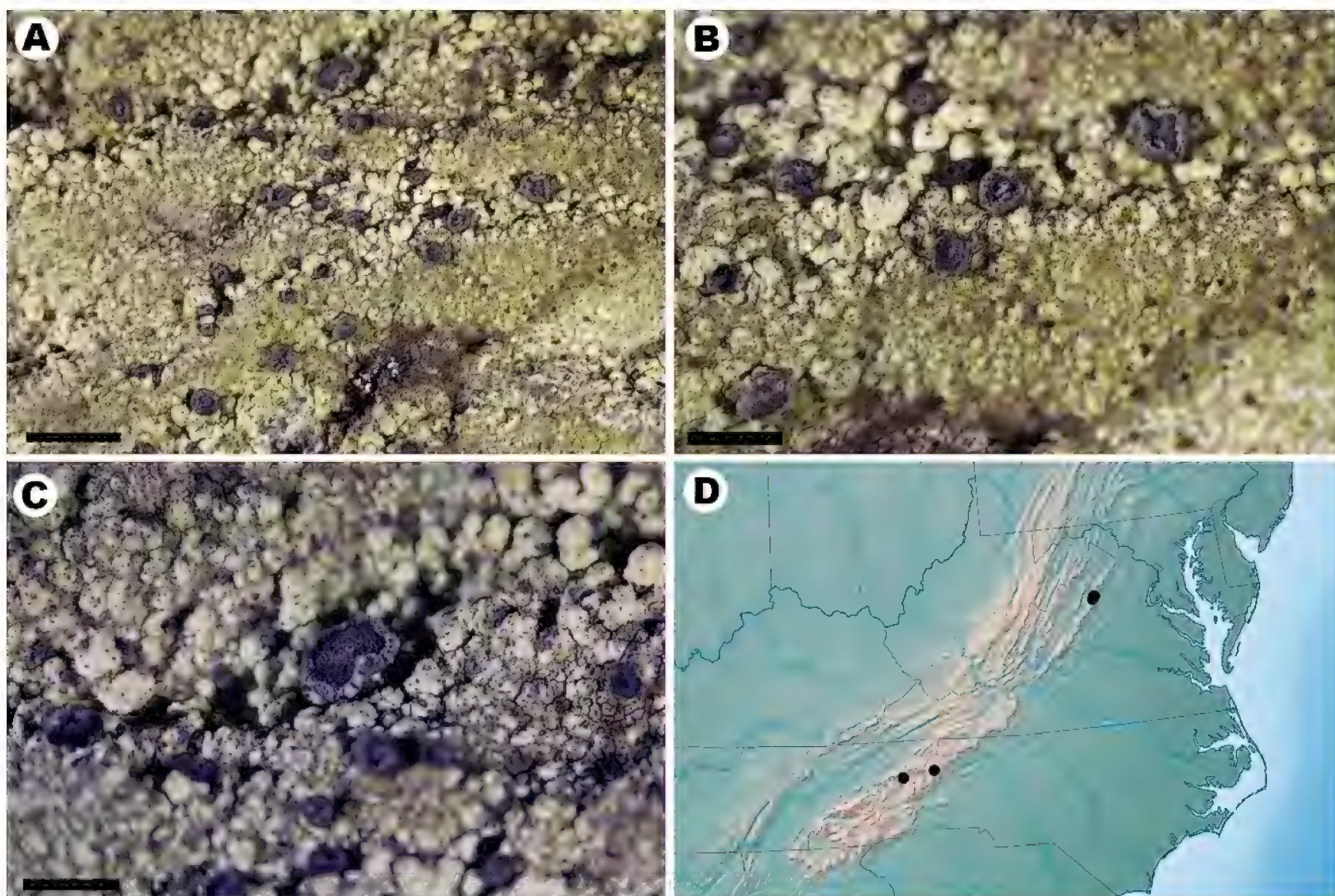


**Figure 9.** Comparative distributions of lichexanthone producing and deficient chemotypes of *Lepra trachythallina* and *Varicellaria velata* in eastern North America based on specimens examined for this study at NY, illustrating the restricted and disjunct distributions of the lichexanthone producing chemotypes compared to the chemotypes without that substance. **A**, *L. trachythallina* without lichexanthone. **B**, *L. trachythallina* with lichexanthone. **C**, *V. velata* without lichexanthone. **D**, *V. velata* with lichexanthone.

## VII – PSORONACTIS DILLENIANA NEW TO EASTERN NORTH AMERICA

*Opegrapha moroziana* Lendemer is a sorediate crustose lichen that occurs on non-calcareous rocks in sheltered or protected microhabitats in the southern Appalachian Mountains of eastern North America (Lendemer 2009). It is unusual among species that grow in such habitats in the region because of the combination of soredia and the production of psoromic acid (Lendemer 2009). During recent fieldwork on high elevation rock outcrops in the central and southern Appalachians, a crustose lichen with a scurfy thallus that vaguely resembled *O. moroziana* was repeatedly encountered. Initially it was thought to be a poorly developed form of *O. moroziana* since it produced psoromic acid. However, discovery of abundant-





**Figure 10.** Morphology and geographic distribution of *Psoronactis dilleniana* (photographs from *Lendemer 66961*). **A**, gross morphology of the thallus and apothecia. **B**, detail of thallus and young apothecia. **C**, detail of mature apothecium. **D**, geographic distribution in North America based on specimens examined for this study. Scales = 2.0 mm in A, 1.0 mm in B and C.

-ly fertile material and comparison with reference material of *O. moroziana* revealed that a very different taxon was involved.

Damien Ertz examined digital images of the material and suggested *Psoronactis dilleniana* (Ach.) Ertz & Tehler as an identification. This was subsequently confirmed by comparison with reference specimens and published descriptions (Cannon et al. 2021, Ertz et al. 2015). The species can be recognized by its scurfy, rough and superficially granular thallus that is dingy pinkish to brownish-gray and when fertile by the rounded, black lecideine apothecia with gray pruina, 4-celled hyaline ascospores that are fusiform or slightly curved, measuring  $18\text{--}32\text{ (–}40) \times 4\text{--}5\text{ }\mu\text{m}$ , and production of psoromic acid (Cannon et al. 2021; see Figure 10 herein). *Psoronactis dilleniana* does not appear to have been previously reported from North America and is here reported from scattered high elevation sites in the Appalachian Mountains (Figure 10D). The species appears to be infrequent but widespread in humid, shaded, overhangs of large non-calcareous rock outcrops and sheltered rock faces between boulders on shaded talus slopes.

*Specimens examined.* – **U.S.A. NORTH CAROLINA.** AVERY CO.: Grandfather Mountain State Park, Grandfather Mountain, Raven Rocks, 14.vi.2020, on rock in overhang, *J.C. Lendemer 66961* (NY). **NORTH CAROLINA.** YANCEY CO.: Pisgah National Forest, Bald Mountains, High Rocks, 3.vii.2020, on rock in overhang, *J.C. Lendemer 66256* & *B. Nelson* (NY). **VIRGINIA.** MADISON CO.: Shenandoah National Park, Central District, SW slopes of Hawksbill Mountain, 9.x.2020, on rock in overhang, *J.C. Lendemer 70120* (NY); Shenandoah National Park, Central District, Hemlock Springs, 24.iv.2021, on rock in overhang, *J.C. Lendemer 70587* (NY).

#### **VIII – ROCKEFELLERA CROSSOPHYLLA REDISCOVERED IN PENNSYLVANIA**

*Rockefellerella crossophylla* (Tuck.) Lendemer & E. Tripp is a morphologically and ecologically distinctive member of the lichen family Pannariaceae and is endemic to eastern North America (Lendemer



et al. 2017). Although it was thought to be extinct (Jørgensen 2000), individuals of the species were subsequently found at scattered locations in the Ozarks, Appalachian Mountains and Canadian Maritimes (Lendemer & Anderson 2008; note the last is no longer extant). The species is now assessed as Endangered by the IUCN Red List (Randlane et al. 2019). In Pennsylvania, *R. crossophylla* has long been known from a single historical collection made at Glen Onoko along the Lehigh River (Lendemer & Anderson 2008). Efforts by the author to find the species at Glen Onoko failed to relocate it, and led to the conclusion that it was extirpated from the state. During a hike in 2018, the author discovered a single colony of the species. Thus *R. crossophylla* is extant in Pennsylvania, and this occurrence is of high conservation concern given the absence of additional extant occurrences in the central and northern Appalachian Mountains (Randlane et al. 2019).

*Specimens examined.* – **U.S.A. PENNSYLVANIA.** CARBON CO.: Glen Onoko, v.1875, on rocks, *E.A. Rau s.n.* (NY). SULLIVAN CO.: Worlds End State Park, 1.i.2018, on sheltered rock face, *J.C. Lendemer 55102* (NY).

#### IX – XENONECTRIELLA STREIMANNII DISCOVERED IN NORTH AMERICA

While inventorying lichens as part of a large-scale project to study biodiversity gradients in the southern Appalachian Mountains (Tripp et al. 2019) a thallus of *Sticta beauvoisii* Delise that was strongly infected with a lichenicolous fungus was found (Figure 11). This discovery was noteworthy because *Sticta* thalli in the region appear to be infrequently infected with lichenicolous fungi, at least to the degree that they are rarely readily visible in the field with the naked eye (Lendemer, unpublished data). Subsequent study of the material revealed that it represents *Xenonectriella streimannii* (S.Y. Kondr., Coppins & D.J. Galloway) Rossman, which is not presently included on the North American checklist (Esslinger 2021).

*Xenonectriella streimannii* can be recognized by its conspicuous reddish-brown perithecia that erupt out of surface of the thallus of the host, ellipsoid to broadly ellipsoid, uniseriate ascospores that turn reddish-brown and become verruculose when mature (Kondratyuk 1996). Reports of the ascospore size vary and ours measure  $13.9\text{--}17.1 \times 7.2\text{--}13.4 \mu\text{m}$ , which is within the range given in the protologue albeit slightly wider ( $(10\text{--})12.7\text{--}16.2 \times (7.0)8.1\text{--}10.1 \mu\text{m}$  *fide* Kondratyuk 1996) but smaller than the range given for material from Russia ( $(9.6\text{--})11.1\text{--}13.7(15.2) \times (6.6\text{--})7.0\text{--}8.0(8.9) \mu\text{m}$ , *fide* Zhurbenko et al. 2020). The species was originally described from Queensland, Australia, as *Pronectria streimannii* S.Y. Kondr., Coppins & D.J. Galloway by Kondratyuk (1996) based on material growing on *Sticta cyphellulata* (Müll. Arg.) Hue. Subsequently it has been reported from Asia, Europe and South America (see Zhurbenko et al. 2020) and multiple morphotypes have been described by Etayo (2017).

*Specimen examined.* – **U.S.A. GEORGIA.** RABUN CO.: Chattahoochee National Forest, S-slopes of Wolf Knob, 0.5 mi S of Patterson Gap Rd. at Patterson Gap, 23.iv.2019, on *Sticta beauvoisii* on rock, *J.C. Lendemer 59844 & M. Hodges* (NY).

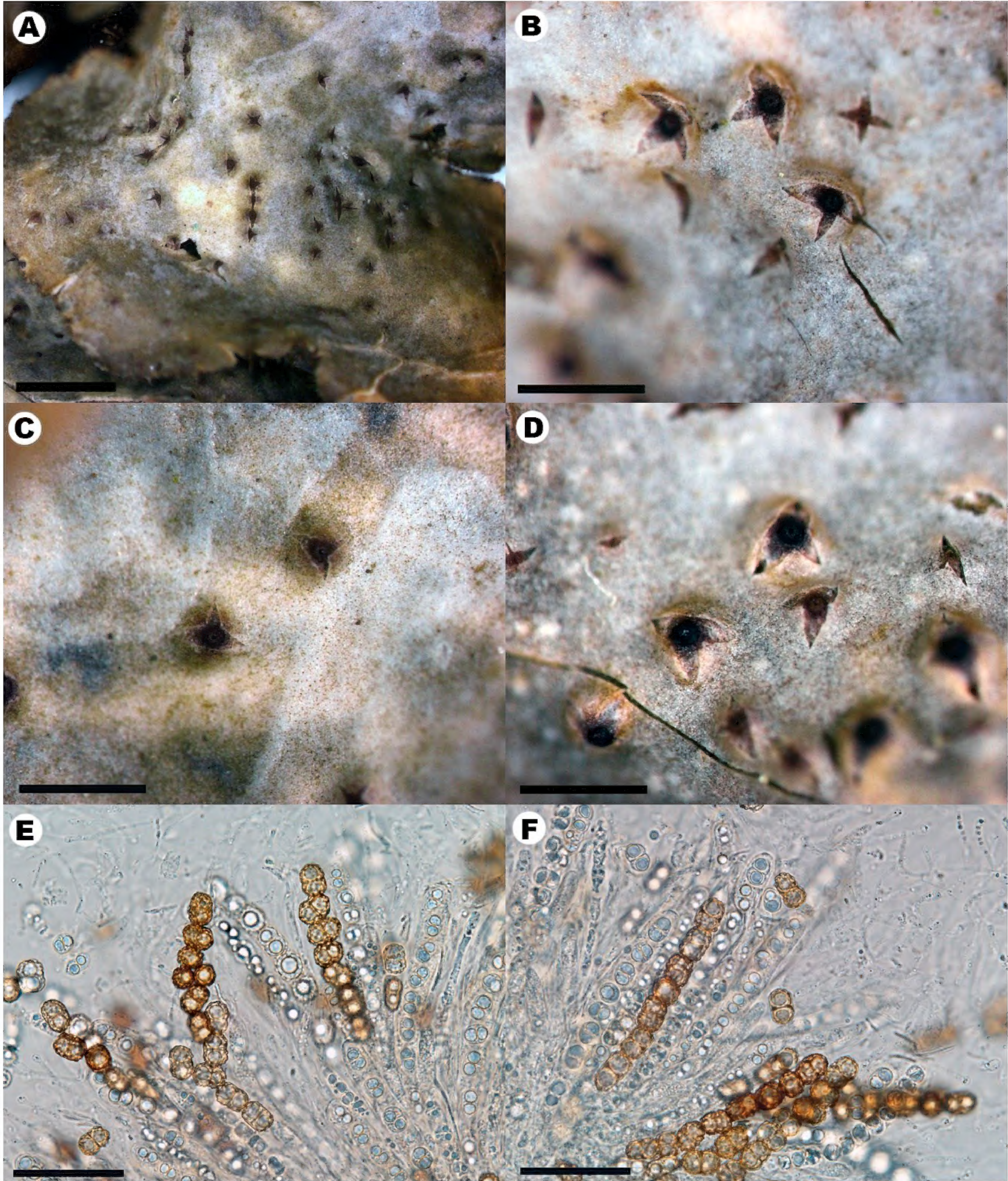
#### ACKNOWLEDGEMENTS

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**Figure 11.** *Xenonectriella streimannii* (all from *Lendemer 59844*, NY). **A**, gross morphology of the infection on thallus of *Sticta beauvoisii*. **B–D**, detail of perithecia erupting from thallus of host. **E and F**, asci and ascospores mounted in water. Scales = 2.0 in A, 1.0 mm in B–D, 50 µm in E and F.



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